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Im Auftrag

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Beverage extraction assembly for extracting a beverage from a particulate
substance contained in a cartridge

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BEVERAGE EXTRACTION ASSEMBLY FOR EXTRACTING A BEVERAGE FROM A PARTICULATE SUBSTANCE CONTAINED IN A CARTRIDGE

The present invention relates to a beverage extraction assembly for application to beverage extraction machines for extracting a beverage from a particulate substance, such as ground coffee, instant coffee, tea, powdered chocolate, powdered milk, and the like, contained in a cartridge.

It is known that machines for extracting a beverage from a particulate substance usually require that the particulate substance is placed into a filtering receptacle installed in the machine. In particular, automatic/semiautomatic espresso coffee machines comprise a filtering receptacle, also called filter holder, in which a dose of ground coffee is placed before the extraction of coffee beverage takes place.

The general steps for extracting a coffee beverage in an espresso coffee machine, which are substantially equivalent to those of other automatic machines for preparing a beverage starting from a powdered substance, comprise a phase of delivering hot water under suitable pressure into an extraction chamber which includes the filtering receptacle, a brewing phase and a phase of conveying the brewed beverage into an external cup or glass, ready to drink.

Ground coffee, as well as other particulate substances for preparing brewed beverages, is usually a single use substance, in that the organoleptic qualities such as taste, aroma and body of the brewed beverage are irremediably lost once ground coffee has been soaked. Accordingly, in espresso coffee machines and in other brewing machines the particulate substance has to be removed after one single brewing. This is the reason why the filtering receptacle housing a dose of ground coffee is usually manually removable from the espresso coffee machine, in order to allow emptying of the receptacle from the used ground coffee and filling it with a new dose of ground coffee.

In order to facilitate the operations of filling and emptying the filtering receptacle, single serving pre-packaged tablets of ground coffee have been provided, consisting of a dose of ground coffee contained in a filtering paper bag or sachet, to be placed directly in a filter holder of the espresso coffee machine. While this arrangement has resulted handy, it is affected by some drawbacks. In particular, the tablet is not air-tight and accordingly a second air-tight packaging must be provided for enclosing each dose, in order to keep the tablet uncontaminated from the external environment during storage.

Moreover, the user's hands come into contact with the tablet when the tablet is placed on the filter holder so that hygiene requirements are not fully assured.

In the past years, disposable capsules containing ground coffee have been also provided. Such capsules, generally having a frustum shape, are made of plastics or aluminum and provide a better air-tight barrier to the external environment than the filtering paper used in tablets.

A known capsule has a top surface that is pierceable by an injection needle/nozzle of the espresso coffee machine, in order to inject water under pressure inside the capsule, and a bottom surface comprising weakened zones which tear under pressure of percolation fluids. An internal filter is also provided inside the capsule for preventing solid substances from being ejected from the capsule together with the coffee beverage.

Another known capsule comprises a cylindrical body made of polypropylene, with a top and a bottom surface having a plurality of openings for distributing hot water throughout the dose of ground coffee, and comprising a sheet of paper filter for blocking passage of ground coffee outside the openings of the bottom surface during the extraction phase. These capsules have usually to be placed into a further packaging, such as a multilayered plastic sachet.

In order to prepare a coffee beverage, the known capsules and

cartridges are placed into the filter holder, that constitutes an extraction chamber for coffee when it is installed on the coffee machine. During the extraction phase, the percolation fluids may come into contact with internal surfaces of the extraction chamber before definitively flowing out into the external coffee cup. Such contact contaminates the extraction chamber as well as the filter holder and after a number of coffee extraction operations the quality of the beverage is greatly reduced, suffering from residuals and contaminants in the extraction chamber.

Accordingly, the extraction assembly, comprising the extraction chamber and the filter holder, has to be accurately cleaned after a certain number of coffee extraction operations; in addition, decalcification must be performed on a regular basis.

Even when such cleaning operations are regularly carried out, the fluid turbulence inside the extraction chamber of the machine or the insufficient fluid-tight seal at the opened top surface of the capsule during water injection causes either the extracted beverage or the injected water to lap portions of the external surface of the capsule itself, thus jeopardizing the extraction hygiene requirements.

Another drawback of known capsules is that they do not retain percolation fluid residuals inside the capsule, in that perforations or openings on the top surface and/or on the bottom surface of the capsules provide for an escape for fluid residuals when the extraction is terminated and/or when the capsule is removed from the machine, causing the capsule to drip and dirt the surroundings of the coffee machine.

In addition, the known capsules and espresso coffee machines do not suffer from a limited hygienic character only, but they are often affected by a not so efficient distribution of hot water into the ground coffee and/or delivery of the coffee beverage.

In fact, in known capsules having a frustum shape, the hot water is injected into the internal volume by means of a nozzle that pierces the top

surface, which has a smaller diameter than the bottom surface, so that hot water is sprayed from a single point rather than being evenly showered onto the whole dose of coffee. Accordingly, the hot water washes the coffee particles in an inhomogeneous way.

5 This drawback has been partially solved by the cartridge disclosed in EP-A-1344722, wherein two disks are provided inside the cartridge having a plurality of openings and a plurality of embossings, in order to create a plurality of fluid channels. Unfortunately, such known cartridge has to be pierced on both the upper and the lower surface in order to extract the
10 beverage, and the internal volume of the cartridge has to be burdened with additional elements such as distribution disks.

Yet another drawback of prior art cartridges is that they are not very handy, in that a user must control the insertion direction when he installs the cartridge into an extraction machine. This control may be facilitated by
15 means of a particular shape of the cartridge's receptacle in the machine, but when the user is particularly hurried (for instance, when the user is a barman assigned to continuously and quickly prepare coffee beverages for many customers) even a control of a minor nature is unacceptable.

Aim of the present invention is to overcome the drawbacks of prior
20 art beverage extraction systems by providing an extraction assembly which greatly reduces or eliminates contamination of any component of machines for producing a beverage from a particulate substance.

Within the scope of this aim, an object of the present invention is to provide a universal beverage extraction system, which takes advantage of its
25 contamination-free structure for allowing consecutive extractions of beverages from different kinds of particulate substances.

A second particular object of the present invention is to transfer most of the tasks that are conventionally performed by beverage extraction machines to the cartridges to be used in such extraction machines.

30 Another particular object of the present invention is to guarantee a

high level of preservation of the particulate substance inside the cartridge until the cartridge is installed into the beverage extraction machine, reducing contamination of the particulate deriving from the external environment.

Another object is to simplify use of the cartridge, reducing the
5 number of operations to be carried out for preparing the cartridge to installation into a beverage extraction machine.

A further object is to provide an improved even distribution of the injection fluid throughout the entire dose of particulate substance of the cartridge.

10 Yet another object is to simplify and reduce the internal load of the cartridge and the beverage extraction machine without affecting the quality of the final beverage.

Not least object of the invention is to provide a cartridge and an extraction assembly which speed up the beverage preparation operations.

15 This aim, these objects and other which will become apparent hereinafter are achieved by a beverage extraction assembly for application to beverage extraction machines for extracting a beverage from a particulate substance contained in a cartridge, characterized in that it comprises: a support connectable to a water outlet of a beverage extraction machine; a
20 cartridge holder removably mounted on the support for holding a cartridge containing a particulate substance, the cartridge comprising at least a first cartridge port protruding outwardly from its upper surface for receiving water under pressure; the support comprising a water inlet port connectable to the water outlet, for delivering the water to the first cartridge port, the
25 cartridge holder comprising a bottom aperture for providing an escape for the extracted beverage; the water inlet port of the support comprising means for providing a radial fluid-tight seal between the water inlet port and the first cartridge port.

Further characteristics and advantages of the invention will become
30 better apparent from the following description of preferred but not exclusive

embodiments, illustrated by way of non-limitative embodiments in the accompanying drawings, wherein:

Figure 1 is a perspective view of a cartridge according to a first embodiment of the invention;

5 Figure 2 is a perspective, cross-sectional, exploded view of the cartridge of Figure 1, taken along plane A-A of Figure 1;

Figure 3 is a top view of the cup portion of the cartridge of Figure 1;

Figure 4 is a cross-sectional view of the cup portion of Figure 3, taken along plane B-B;

10 Figure 5 is a perspective cross-sectional view of a cartridge according to a second embodiment of the invention;

Figure 5 is a perspective cross-sectional view of a cartridge according to a second embodiment of the invention;

Figure 6 is a perspective cross-sectional view of a cartridge
15 according to a third embodiment of the invention;

Figure 7 is a perspective broken away view of the shim of Figure 5;

Figure 8 is a perspective view of a cartridge according to a fourth embodiment of the invention;

Figure 9 is a perspective cross-sectional exploded view of the
20 cartridge of Figure 8;

Figure 10 is a perspective cross-sectional view of a cartridge according to a fifth embodiment of the invention;

Figure 11 is a perspective view of the inner side of the lid portion of the cartridge of Figure 10;

25 Figure 12 is a perspective view of a cartridge according to a seventh embodiment of the invention;

Figure 13 is a perspective cross-sectional view of the cartridge of Figure 12, taken along a radial plane;

Figure 14 is a perspective cross-sectional view, taken along a radial
30 plane, of the cartridge according to the seventh embodiment of the invention

in a pierced state;

Figure 15 is a perspective view of the tappet assembly housed in the cartridge of Figure 12;

Figure 16 is a perspective view of an extraction assembly according
5 to a second aspect of the invention;

Figure 17 is an exploded view of the extraction assembly of Figure
16;

Figure 18 is a perspective broken away view of the extraction
assembly of Figure 16 arranged in the beverage extraction position, having a
10 cartridge installed therein;

Figure 19 is a perspective broken away view of an extraction
assembly arranged in the beverage extraction position, having a discoidal
cartridge installed therein;

Figure 20 is a perspective broken away view of the extraction
15 assembly of Figure 16 arranged in the cartridge expulsion position;

Figure 21 is a bottom view of the nozzle used in the extraction
assembly of Figure 16;

Figure 22 is a partial cross-sectional lateral view of the nozzle used
in the extraction assembly of Figure 16;

20 Figure 23 is a cross-sectional lateral view of the nozzle used in the
extraction assembly of Figure 19;

Figure 24 is a broken away view of an extraction assembly according
to a further embodiment of the invention, in which the capsule of Figure 12
is installed;

25 Figure 25 is a broken away view of the extraction assembly of Figure
24 when it is arranged in the beverage extraction position;

Figure 26 is a side cross-sectional view of the injection nozzle used
in the extraction assembly of Figure 24;

Figure 27 is a perspective cross-sectional view, taken along a radial
30 plane, of the cartridge according to a further embodiment of the invention;

Figure 28 is a broken away view of an extraction assembly according to a further embodiment of the invention, in which the cartridge of Figure 27 is installed.

With reference to Figures 1 and 2, a cartridge **1** is shown according to
5 a first preferred embodiment of the present invention. The cartridge has a generally cylindrical shape and comprises a cup portion **2** and a lid portion **3** fixed thereon.

In particular, the cup portion **2** comprises a substantially circular base **7**, a cylindrical sidewall **8** extending from base **7** and a rim **9a**, which is
10 disposed substantially opposite to the base **7** and defines an open end of the cup portion **2**.

An internal volume is defined by the cup base **7**, the sidewall **8** and the lid portion **3**, when the lid portion is fixed on the cup portion. A dose of ground coffee **4** is housed in such internal volume and it is sandwiched
15 between filtering means, preferably consisting of a first paper filter **5b** and a second paper filter **5a**. In an alternative embodiment, a tablet of a known kind can be provided, as it will be described hereafter.

The cup portion **2** comprises a cup port **6a**, which is preferably located in a central region of the cup base **7** and protrudes outwardly with
20 respect to the internal volume of the cartridge, forming a spout. As shown in Figure 2, the cup port **6a** has a substantially cylindrical shape and provides for open access to the internal volume of the cartridge, thus allowing passage of fluids to or from the internal volume of the cartridge. To this aim, the opening **103a** is provided on the cup base **7** in correspondence of the cup
25 port **6a**, as it is shown in Figure 4.

The cup base **7** optionally comprises a flange **105a**, aligned with sidewall **8** and protruding outwardly with respect to the internal volume of the cartridge. Such flange is preferably provided in order to end up with a protruding shape facilitating and promoting handling and automated
30 production processes. Furthermore the capsule can be placed in a horizontal

position on a table surface without tilting or rolling, it can be packaged and stacked more easily and it can also be "strip" packaged, i.e. fixed and sealed between two strips of polylaminate films..

The lid portion 3 is shaped so as to fit with the open end of the cup portion 2 and comprises a lid base 7b, from which a substantially cylindrical sidewall 105b extends upwardly and slightly outwardly and which is substantially perpendicular to the lid base 7b. The sidewall 105b ends with an annular edge 9b that is located substantially opposite to the lid base 7b and that protrudes outwardly from the sidewall 105b, in order to fit with and lean on the rim 9a of the cup portion 2. Preferably, the annular edge 9b has a substantially stepped cross section, so as to engage with a complementary support located at the rim 9a of the cup portion 2, as depicted in Figure 3. Other cross-sectional shapes of the annular edge 9b and of the rim 9a can be alternatively provided, as long as these shapes allow to fix the lid portion on the cup portion.

In preferred embodiments, the lid portion and the cup portion are welded to each other using an ultrasonic shear-welding technique. Alternatively, other known welding techniques can be used, for instance common ultrasonic welding, hot welding, bonding and so on. The cartridge according to the invention may also be manufactured as a single moulded piece.

The protruding sidewall 105b is preferably provided in order to facilitating and promoting handling and automated production processes, as well as to dissociate the shear welding region away from the coffee tablet, thus minimizing interferences of migrating coffee particles with the plastic weld, which might compromise its tight sealing characteristics.

In the preferred embodiment depicted in Figures 1 and 2, the lid portion 3 comprises a lid port 6b in a central region of its base 7b, having a generally cylindrical shape and protruding from base 7b outwardly with respect to the internal volume of the cartridge. The lid port 6b provides for

open access to the internal volume of the cartridge, thus allowing passage of fluids to or from the internal volume. To this aim, the opening **103b** is provided on the lid base **7b** in correspondence of the lid port **6b**, as shown in Figure 2.

5 In alternative embodiments, described hereafter, the lid port does not protrude from the lid base **7b** or is normally closed, being pierceable by an injection needle or nozzle during the extraction phase. Alternative embodiments of a similar kind will be presented hereafter.

In the cartridges according to the invention, either the lid port **6b** or
10 the cup port **6a** may comprise hurdles for deviating a fluid flow. In particular, referring back to the embodiment of Figures 2-4, a first barrier **104a** is provided on the internal side of the cup base **7** so that it radially crosses the central opening **103a** from which the spout **6a** protrudes, and second barriers **106a**, **107a** are provided on the internal surface of the cup
15 port **6a** at a distance from the first barrier and from the opening **103a**.

Preferably, second barriers **106a** and **107a** face each other and protrude from the internal surface of the cup port **6a** so as to define a sort of zigzag path for the fluid passing through the cup port **6a**, thus breaking any direct fluid flow to or from the internal volume of the cartridge and avoiding
20 exceedingly accelerated fluid flow, which may cause jet-spray effects such as spattering.

The first barrier **104a** is particularly useful for either deviating the fluid flow or providing a support against filter paper deformation that may result from the hydraulic extraction fluid pressure. Accordingly, obstruction
25 of the openings **103a** and possible breaking of the filter paper are prevented.

Additionally or alternatively, corresponding fluid flow barriers **104b** and **107b** are also provided at lid port **6b**, as seen in Figure 2. In particular, the barrier **104b** spans the lid opening **103b**, while the barrier **107b** protrudes from the internal surface of the lid port **6b**, facing an identical barrier in
30 order to define a fluid flow pathway substantially analogous to that formed

inside the cup port **6a**.

Notwithstanding preferred embodiments of the cartridge according to the invention comprise fluid flow hurdles as depicted in Figures 2-4, the skilled in the art easily appreciates that alternative arrangements or shapes of fluid flow hurdles can be used for the same purpose. For instance, a cross-shaped fluid flow barrier may be provided, so as to support the paper filter and break direct fluid flow into four separate flows. Alternatively, radial projections formed around the lid or the cup opening and radially protruding towards the center of such opening may be provided, as it will be described hereinafter with reference to Figure 27.

Fluid flow hurdles may not be directly formed on the internal surface of the cartridge, but they may be a separate means which can be inserted and fixedly attached to an inlet or an outlet port of the cartridge. For instance, a small plastic tube with both open ends closed by a fluid permeable filter material (for instance, films of thermoplastic sieve material or open mazed tissue or paper). An example of a separate fluid flow hurdle will be described hereinafter with reference to Figure 27.

Moreover, the fluid flow hurdles may be provided at both the lid and cup ports, at only one of such ports, or may not be provided at all, according to fluid flow requirements.

The cup portion **6a** further comprises a plurality of ridges **101a** directly formed on the base **7** and protruding towards the internal volume of the cartridge, in particular towards the external surface of the paper filter **5a**. The ridges **101a** directly contact paper filter **5a** so as to form a plurality of small channels **102a**, **102b**, which put in a fluid communication the whole bottom surface of the filter-coffee assembly **4**, **5a** with the cup port **6a**. Such channels, preferably, have an average width/height of about 1mm.

Similarly, ridges **101b** are provided on the lid portion **3** which protrude towards the internal volume of the cartridge, in particular towards the upper surface of the paper filter **5b**. A plurality of small channels is

accordingly provided between the filter **5b** and the lid base **7b**, connecting the lid port **6b** to the whole top surface of the filter-coffee assembly **4, 5b**.

In alternative embodiments, small fluid channels may be provided on cup portion only, or on lid portion only, or they may not be provided at all.

5 In such cases, a reduced number of ridges is preferably formed on either the cup base or the lid base, and they protrude towards the internal volume of the cartridge in order to form an air space between the cup/lid base and the filtering means. An exemplary arrangement of such kind will be explained hereafter with reference to Figure 11.

10 Alternatively, in order to provide a fine canalization on at least a portion of the internal surface of the cartridge facing one of the top surface or the bottom surface of the dose comprising the ground coffee and the filtering means, a disc of porous material may be arranged between such dose and cup port or the lid port. Preferably, such disc extends throughout
15 the top or the bottom surface of the dose.

Even though not explicitly shown in Figures 1-4, the lid port and/or the cup port are preferably plugged by a film, for instance made of multilayered plastics, which can be manually removed or can be pierced or torn by the machine during the extraction phase.

20 Alternatively, the lid port or the cup port may be plugged by an integrated surface created during the manufacturing of the lid portion or by a rubber plug or seal, to be described thereafter, or the entire cartridge may be kept in a sachet or packaging to be manually opened before use. The sachet or packaging may be made of a poly laminate vacuumed or filled with an
25 inert gas under pressure (such as in Modified Atmosphere Packaging or MAP techniques).

Either the lid port or the cup port may be alternatively sealed by means of edible solid substances (e.g. polysaccharides, proteins and lipids) that are air-impermeable and water-soluble or that melt at the temperature of
30 the inlet water.

The cartridge 1 is preferably made of polypropylene and it is manufactured using known injection moulding techniques. Anyway, this cartridge as well as any cartridge according to the invention may be made of any material such as: other thermoplastic materials, for instance PET; 5 elastomeric-thermoplastic materials or TPEs, for instance, SANTOPRENE, i.e. a mixture of non interlaced EPDM and polypropylene; thermosetting compositions, for instance, a polyester; rubbers or elastomers, for instance, silicone or MVQ; poly laminate thermoplastic materials, for instance a composite sheet made of PE, PET and PVDC; aluminium; other 10 poly laminate materials, for instance, a composite sheet made of PE, PET and aluminium. The cartridge 1 may also be manufactured using other techniques, such as thermoforming.

The main body of an exemplary cartridge such as the one depicted in figure 1 is, for instance, 30-35mm high and 35-40mm wide, and the lid port 15 and the cup port are about 7-8mm high and 8-10mm wide. However, the skilled in the art readily understands that the size of the cartridges according to the invention may be different, according to the extraction requirements and the structure of the beverage extraction machine.

Having now defined the main characteristics of cartridge 1, it can be 20 appreciated that this cartridge eliminates the traditional contamination of the extraction chamber of a coffee machine, in that the cup port/spout 6a acts as an outlet for directing the extracted beverage directly into an external cup that is then used for drinking. The spout 6a is accordingly shaped so as to fit in known filter holders or so as to outwardly protrude with respect to 25 purpose-built filter holders, thus keeping perfectly clean the internal surfaces of the filter holder and prevent the extracted beverage exiting the cartridge from contacting such surfaces.

Additionally, the small channels directly formed on the internal surface of the cup portion allow to eliminate additional fluid director 30 members from the inside of the cartridge and advantageously combine with

the cup port so as to define an integrated conveyor for the extracted beverage. At the same time, the small channels allow to keep the internal pressure level drop of the cartridge at a substantially lower value between upper zone and lower zone of the coffee cake, so that the full volume of ground coffee is exploited and the resulting beverage has enhanced organoleptic qualities.

For functional reasons, it is preferable to keep the space between the coffee cake and base of the cup portion or the lid portion as little as possible.

Another improvement involved by the particular cartridge of Figure 1 is that it is reversible, i.e. it can be inserted also upside-down. In fact, the main body of the cartridge is shaped so as to be substantially symmetrical with respect to an virtual plane perpendicular to the water injection axis. In particular, the cup port **6a** and the lid port **6b** are substantially identical in shape and size, they are aligned on a same water injection axis and the height of flange **105a** is substantially equal to the height of the cylindrical sidewall **105b**, as illustrated in Figure 2. Advantageously, a fine canalisation is provided on both the internal surfaces of the cup portion and of the lid portion.

Accordingly, the cartridge **1** can be installed in a filtering receptacle regardless of which port will act as the inlet port and which port will act as the outlet port, thus greatly facilitating the operation of inserting the cartridge into an extraction machine.

While characteristics have been shown with reference to the exemplary embodiment of Figures 1-4, several alternative embodiments of the invention can be provided by either suitably combining the fundamental characteristics already illustrated or by adding other features still falling within the scope of the invention.

With reference to Figure 5, a second preferred embodiment of the invention is illustrated. In particular, Figure 5 is a cross-sectional view of a cartridge **11** which, even though the main body is externally similar to that

depicted in Figure 1, features internal variants.

While only a sectional view of cartridge 11 is shown in Figure 5, it is understood that this view is taken along a virtual radial plane halving the whole actual cartridge, which is not shown in the Figures for clarity reasons. It is clear that the skilled in the art has no difficulty in picturing the structure of the whole cartridge 11 starting from the sectional view of Figure 5.

The cartridge 11 has a generally cylindrical shape and comprises a cup portion 12 and a lid portion 13. The cup portion 12 comprises a base 17, a sidewall 18 and a rim 19a that is disposed substantially opposite to the base 17 and defines an open end of the cup portion 12.

An internal volume is defined by the cup base 17, the sidewall 18 and the lid portion 13, when the lid portion is mounted on the open end of the cup portion 12. A dose of ground coffee is housed in such internal volume, enclosed by filtering means either in a way similar to that depicted in Figure 2 or as in a tablet or cake of a known kind, as it will be better described hereafter.

In Figure 5, both the ground coffee and the filtering means have been omitted for simplicity, but it is intended that they substantially fill the internal volume of the cartridge, as it occurs in the embodiment of Figure 2.

The cup portion 12 comprises a cup port 16a, preferably located in a central region of the cup base 17 and protruding outwardly with respect to the internal volume of the cartridge. The cup port 16a has a substantially cylindrical shape and provides for open access to the internal volume of the cartridge, thus allowing passage of fluids to or from the internal volume of the cartridge. To this aim, an opening 113a is provided on the cup base 17 in correspondence of the cup port 16a.

The cup base 17 preferably comprises a flange 115a, aligned with the sidewall 18 and protruding outwardly with respect to the internal volume of the cartridge.

The lid portion 13 is shaped so as to fit with the open end of the cup

portion 12 and comprises a lid base 17b, from which a substantially cylindrical sidewall 115b extends upwardly and slightly outwardly. The sidewall 115b ends with an annular edge 19b that is located substantially opposite to lid base 17b and that protrudes outwardly from the sidewall 115b, in order to fit with and lean on rim 19a of the cup portion 12.

Preferably, the annular edge 19b has a substantially stepped cross section, so as to engage with a complementary support located at the rim 19a of the cup portion 12, as depicted in Figure 5. Alternatively, other cross-sectional shapes of the annular edge 19b and of the rim 19a can be provided, as long as such shapes allow to fix the lid portion on the cup portion.

The lid portion 13 further comprises a normally closed lid port 16b, preferably located in a central region of the base 17b and protruding outwardly with respect to the internal volume of the cartridge 11. The wording "normally closed" as intended herein indicates a port which is air-tight sealed before extraction and it is opened either manually by a user or automatically by the beverage extraction machine, for example by piercing the surface that plugs the port.

In the embodiment of Figure 5, the lid port 16b is plugged by a weakened small surface 14 that is integrated with the lid port 16b. Alternatively, the lid port may be plugged by a plastic film welded on the external mouth of the lid port or by a rubber or rubber-like plug or seal, described hereafter.

The internal surface of the lid port 16b is substantially smooth, but fluid flow hurdles can be alternatively provided as those described with reference to the embodiment of Figure 2.

The cup portion 12 comprises a cup port 16a, located on the cup base 17 and preferably having a substantially cylindrical shape. In the preferred embodiment depicted in Figure 5, the cup port 16a is located in the central region of the base 17, protrudes outwardly with respect to the internal volume of the cartridge 11 and comprises hurdles 114, 117a and 117b for

breaking direct fluid flow passing through the cup port.

The first hurdle **114** is formed inside the cup port **16a** in the proximity of its output mouth so as to radially cross the internal volume of the cup port, while the second hurdles **117a** and **117b** flange out the internal surface of the cup port and face each other.

Similarly to the embodiment depicted in Figure 2, the cup portion **12** comprises a plurality of ridges **111a** that are directly formed on the internal side of the base **17** and protrude towards the internal volume of the cartridge. The ridges **111a** define a plurality of small channels **112a**, **112b** between the cup base **17** and the filtering means, for conveying the extracted beverage to the cup port **16a**.

In the particular embodiment shown in Figure 5, unlike lid portion **3**, a fine canalisation is not provided between the lid portion and the assembly consisting of the ground coffee and the filtering means. Instead, sparse ridges **111b** are provided on the bottom side of the lid portion **13**, serving the purpose of creating a very small gap between the lid portion and the ground coffee. However, it is clear that as an alternative to this arrangement a canalisation may still be provided, as described above with reference to the lid portion **3**.

Advantageously, the cartridge **11** comprises valve means, for regulating the fluid flow passage through the cup port **16a**. The valve means are particularly conceived for application to the cup port, but they can be applied to both the cup port and the lid port of a cartridge according to the invention, or to the lid port only, according to the functional requirements of the cartridge.

In the embodiment shown in Figure 5, the valve means lean on an annular recess **15**, that is formed around the opening **113a** and cover opening **113a**. To this aim, the thickness of the base **17** preferably tapers from the cup port **16a** towards the periphery, to allow the formation of the recess **15**.

The valve means preferably comprises a rubber (e.g. silicone rubber),

rubber-like, elastomeric or plastic pad or disc having a narrow through slit or orifice formed therein connecting a top surface to a bottom surface of the pad. If no axial pressure is applied to the pad, the slit provides for an air-tight seal, whereas if an axial pressure is applied, such as the pressure of
5 percolation fluids extracted from the ground coffee, a portion of the pad warps and the slit slightly widens, thus allowing passage of the percolation fluids, i.e. of the beverage.

According to the particular embodiment depicted in Figure 5, the valve means comprise a rubber pad or disc **116**, leaning on the recess **15** so
10 as to air-tightly close the aperture **113a** of the cup port and acting as a septum. While the pad **116** is described as simply leaning on the recess **15**, it may optionally be bonded to such recess or otherwise fixed using known techniques.

The pad **116** comprises a top circular surface and a bottom circular
15 surface and a slit **118** that axially traverses the pad from the centre of the top surface to the centre of the bottom surface.

The slit **118** is a pre-pierced one and it is preferably made using a thin needle. The slit may alternatively be a radial linear or cross-shaped cut or incision, or a plurality of slits may be provided through the pad, as long as
20 these slits, cuts or incisions do not substantially allow passage of air inside the cartridge when the cartridge is not under fluid pressure and allow passage of percolation fluids during the beverage extraction phase.

In order to provide a support for the filtering means enclosing the ground coffee and to convey the extracted beverage to the pad **116**, a shim
25 **119** is advantageously mounted on the cup base **17** and upstream of the pad **116**.

With particular reference to the broken away view of Figure 7, the shim **119** comprises a bottom surface that faces the pad **116** and that is shaped so as to define fluid flow channels **319** between the shim and the pad:
30 to this aim, the bottom surface of the shim **119** comprises radially oriented

ridges 219.

The top surface of the shim 119 comprises ribs for supporting the coffee-filtering means assembly, which are preferably sized so that the thickness of the shim 119 is substantially equal to the height of the ridges 111a of the cup portion 12.

In alternative embodiments, not shown in the Figures, the shim may comprise through holes for conveying the percolation fluids to the rubber pad, or it may be substituted by any other supporting means that separate the dose of ground coffee from the rubber pad, such as those depicted in Figure 27 to be described hereinafter.

Yet in another embodiment, the valve means do not comprise a separate shim at all. For instance, a third embodiment of the invention comprising such alternative valve means comprises only a pad or disc, made of rubber, rubber-like, elastomeric, or whichever resilient material.

In particular, with reference to Figure 6, a cartridge 21 according to a third preferred embodiment of the invention comprises a cylindrically shaped cup portion 22, comprising a base 27, a sidewall 28 and an open end on which a lid portion 23 is engaged so as to define an internal volume of the cartridge. Inside the cartridge, a dose of ground coffee and the corresponding filtering means are provided as in the previously described cartridges, but they are not shown in Figure 6, for simplicity.

The lid portion 23 comprises a normally closed lid port 26b and it has substantially the same features of the already described lid portion 13.

The cup portion 22 comprises a cup port 26a, inside which fluid flow hurdles 124, 127a and 127b are provided. Moreover, the top surface of the base 27 comprises a plurality of ridges 121, which ridges are distributed throughout the surface of the base 27 substantially as ridges 111a and which converge to an annular recess 25. A circular rubber pad 126 leans on the recess 25 so as to air-tightly plug the aperture 123a of the cup port 26a. Notwithstanding pad 126 is herein described as simply leaning on recess 25,

it may optionally be bonded to an edge of such recess or be otherwise fixed through known means.

Similarly to pad 116, pad 126 comprises a through slit 128 at its centre, which slit is normally closed and slightly widens, thus allowing
5 passage of the percolation fluids, during the beverage extraction phase.

In order to support the dose of ground coffee and the filtering means, the pad 126 preferably comprises ribs 129, which are directly formed on its top surface and shaped so as to allow the passage of fluids directly deriving from the coffee/filter assembly and from the channels defined by ridges 121.

10 Pads 116 and 126 have been described as being made of rubber, elastomeric or other flexible materials. The elastic properties of such materials allow a pre-pierced orifice or channel such as the slit 118 or the slit 128 to act as an air-tight seal, but at the same time allow to readily respond to pressure stresses directed either towards or from the internal volume of the
15 cartridge. In other words, such pads act as valves or baffles.

Therefore, a cartridge comprising such pads requires no means for plugging the cup port - or the lid port, if the pad is applied to the lid port in a way similar to that described above -, such as films or pierceable diaphragms. At the same time, after the extraction phase has terminated, the
20 sudden fall of internal pressure causes the slit to return in the initial rest condition, thus preventing possible internal fluid residuals to drip out of the cartridge.

Beyond its valve-like functioning that protects the cartridge from negative environment influences, at the same time permitting degassing of
25 the cartridge and the extraction fluid to drop after extraction, the above described pad also allows the insertion of liquid inert gas from the outside by means of a hollow needle during the packaging phase (MAP), in order to condition the capsule and prepare it for longer storage periods. The rubber pad then closes automatically by its own elasticity after the needle has been
30 pulled out. The same needle may be the one that pierces the pad so as to form

the slit referred to above.

At the same time, another important advantage brought by pads according to the invention is the great improvement in the forming and stability of the appreciated cream layer on top of the extraction beverage, which is usually identified with the Italian term "crema" when referred to espresso coffee extraction methods.

The espresso extraction method results in a polyphasic beverage constituted by a foam layer of small bubbles with dispersed fine particles that create the typical and particular tiger-tail pattern on top of an emulsion of microscopic oil droplets in an aqueous multi-component solution with dispersed gas bubbles and solid particles.

The foam formation is related to surfactants naturally present in coffee and to a number of phenomena which are triggered by espresso extraction methods.

The supernatant foam of espresso coffee or crema is an extremely important organoleptic characteristic and represents a mark of distinction between espresso coffee and other preparations.

It is well known that the foam characteristics are the signature of a perfect preparation, being any error (for instance in coffee grinding, water temperature, water pressure, percolation time and/or beverage volume, etc) or any change (coffee blend, roasting, etc.) immediately denounced by the colour, the texture and the persistence of espresso foam.

As described above, the valve means according to the preferred embodiment of the invention comprise at least a rubber or rubber-like pad or disc having a through slit whose diameter is very small, e.g. in the order of 0,1 to 0,5 mm when it is opened. Forcing the extracted coffee through it has been found to greatly increase the density and the stability of the crema. This effect is a very advantageous one since, through the integration of a means of a relatively light weight and of simple nature, it is possible to achieve an important effect that characterizes the quality of an espresso coffee beverage.

Moreover, since the rubber pad for crema formation is integrated with the cartridge, which is generally a disposable one, it is guaranteed that the extracted espresso coffee has a layer of crema of the best quality, contrary to the known espresso coffee machines in which the devices that enhance the formation of crema are part of the machines, they are used for a great number of extraction processes and may deteriorate the quality of the extracted coffee over time.

Cartridges according to the invention are not to be limited to the substantially cylindrical cartridges described here above. Particularly, the term "cylinder" has to be read in a broad general meaning and indicates the surface traced by any line moving parallel to a fixed axis and intercepting a closed line. For instance, the main body of the cartridge according to particular embodiments of the invention can be either parallelepiped-shaped or discoid-shaped, too. Furthermore, the term "substantially cylindrical" also indicates cylindrical cartridges having a slight frustum shape, that is to say, for instance, the slope of the sidewall of a cartridge according to the invention can deviate for 1-2 degrees from a perfect cylindrical surface.

A parallelepiped-shaped cartridge, not shown in the Figures, is particularly a preferred one when small space occupancy is required.

A discoid-shaped cartridge, instead, can be advantageously provided in the alternative for other reasons, which will be now explained. An exemplary embodiment of the invention in which the main body of the cartridge is substantially discoid-shaped is depicted in Figures 8 and 9. A cartridge **31** of this kind embodies some of the features of the above cartridges, in particular it comprises a cup portion **32** and a lid portion **33**, both of them having substantially the shape of a dish.

The cup portion **32** comprises a base **37**, an annular sidewall and a flanged rim **39a** that is directed substantially parallel to the base **37** and, similarly, the lid portion **33** comprises a base, a sidewall and a flanged rim **39b** that is shaped so as to engage with the rim **39a**, thus defining an internal

volume of the cartridge. The internal volume of the cartridge is shaped so as to fully house a ground coffee tablet or cake 34 of a known kind, such as the tablet called E.S.E.[®].

Such known tablet comprises a dose of ground coffee encapsulated
5 within a filter paper sachet, whose peripheral edge is tightly retained by rims 39a and 39b when the cartridge 31 is in the assembled condition. Rims 39a and 39b may be reciprocally fixed using any known method such as ultrasonic welding, hot element welding, or other welding techniques, gluing or combinations of these with common border forging or deforming
10 methods.

The cup portion 32 further comprises a substantially cylindrical cup port 36a protruding outwardly with respect to the internal volume of the cartridge 31, which is advantageously provided with inside hurdles 137a and 134a for breaking direct fluid flows passing through the cup port, which are
15 similar to the above described hurdles 117a, 117b, 114.

The base 37 comprises a plurality of ridges 131 distributed on its planar inner side, which define a plurality of small channels between the tablet 34 and the base 37. The ridges 131 surround a central annular recess 35, similar to the above described recesses 15 and 25, on which a rubber pad
20 136 leans.

The pad 136 has a through, normally closed slit at its centre and supporting ribs on its top surface for supporting the tablet 34 and allowing fluid passage there-between. It is seen that the pad 136 is similar to the above described pad 126.

25 A lid port 36b protrudes from the central region of the lid portion 33 and comprises reciprocally facing hurdles 137b on its internal surface.

Figure 9 is a cross-sectional view of cartridge 31 and, as such, shows only one hurdle 137b, but it is understood that an identical hurdle is present on the opposite side of the internal surface of the lid port that faces the
30 depicted one. Moreover, the opening from which the lid port 36b protrudes

out is bridged by a fluid flow barrier **134b**, that is substantially analogous to the above described barrier **104b**.

The lid port **36b** is plugged by a film of aluminium or poly laminate plastics **38**, that forms an air-tight seal for the lid port before installing the
5 cartridge into an espresso coffee machine. The film **38** is preferably pierceable by the injection needle of the machine, but a manually removable film may be provided in the alternative.

As in the cartridges depicted in Figures 5 and 6, the lid portion **33** comprises sparse ridges on the surface directed towards the internal volume,
10 which define a very small gap between the coffee tablet **34** and the lid portion itself.

The cartridge **31** is particularly advantageous in that it is fully compatible with existing coffee tablets. The manufacturing process of this cartridge is also sped up, since no further filtering means have to be inserted
15 into the cartridge.

Moreover, it is seen that the cartridge **31**, as well as the other cartridges described above, is an all-in-one cartridge, that is to say a cartridge in which most of functional features of standard espresso coffee machine, such as filtering, water distribution, crema enhancement and
20 beverage delivery are integrated into the cartridge itself. The espresso coffee machine functions are mainly to support the cartridge and to inject water under pressure inside it.

Figure 10 is a cross-sectional view of a cartridge **41** according to yet another embodiment of the present invention. This cartridge comprises most
25 of the features of cartridge **1**, that is to say a cylindrical cup portion **42** whose base **47** comprises a plurality of ridges **141a** and a spout **46a** with fluid flow hurdles **144** and **147**, a dose of ground coffee **4** and filter paper sheets **5a** and **5b**. An aluminium or multilayered plastics film **45** plugs the external mouth of the spout **46a** and it is manually removable.

30 Differently from the embodiment of cartridge **1**, the lid portion **43**

having a substantially flat shape is provided, comprising a lid port **46b** which only slightly protrudes from the plane of the lid portion and an annular edge **49b** that slightly protrudes from the contour of the lid portion.

With reference to Figures 10 and 11, the inner side of the lid portion **43** comprises sparse radial ridges **141b** that slightly protrude towards the internal volume of the cartridge, so as to create a small gap between the upper filtering means **5b** and the lid portion **43**.

Moreover, the lid portion **43** comprises a rubber/rubber-like plug or seal **48** that engages the mouth defined by the lid port **46b**. The plug **48** is preferably made of a thermoplastic elastomer (TPE) such as EPR or SBS and has a central thinner portion that is pierceable, for instance by an injection needle or a nozzle of the espresso coffee machine, and has a thicker portion surrounding such central portion that grips the mouth of the lid port **46b**.

The thicker and central portions of the plug **48** are sized so as to sealingly engage with the tube or nozzle that delivers water to the cartridge. In other words, the plug **48** acts as a radial fluid-tight seal for the injection tube or nozzle, thus preventing the injected water to splash out of the lid port **46b** during the beverage extraction phase.

As the extraction phase is terminated and the cartridge **41** is separated from the injection nozzle, the plug **48** elastically returns to a rest position due to its resilient nature and, even though it has been pierced, it is a good retainer for solid and fluid residuals, which are kept inside the cartridge as soon as it is removed from the machine.

While the plug **48** has been illustrated inside the cartridge **41**, it is understood that such plug can be applied to any other cartridge according to the invention, such as to the cartridges previously described.

Figure 27 depicts a cartridge **81** according to a further embodiment of the invention. This cartridge comprises features substantially corresponding to those of cartridge **21**, that is to say a cylindrical cup portion **82a** whose base **87a** comprises a plurality of ridges **181** and channels **182** directly

formed thereon and an externally protruding cup port **86a**, a lid portion **83a** being fixedly attached to the upper rim of the cup portion **82a** so as to define an internal volume in which a cake of ground coffee and filtering means (not shown) are housed.

5 The lid portion **83a** comprises a base **87b**, on which sparse ridges are formed similar to ridges **111b**, and comprises a normally closed lid port **86b**, which is preferably located in a central region of the base **87b** and protrudes outwardly with respect to the internal volume of the cartridge **81**. The lid port **86b** is plugged by an aluminium or polylaminated plastics film.

10 The internal surface of the lid port **86b** is substantially smooth and a cross-shaped fluid flow hurdle **89** quarters the opening **183b** from which the lid port **86b** protrudes. The hurdle **89** preferably protrudes towards the internal volume of the cartridge, so that the filtering means that covers the cake of particulate substance is kept at a distance away from the base **87b** of
15 the lid portion **83a**.

 The diameter of the lid port **86b** is generally wider than the ones of the other lid ports described above, in order to completely receive a water injection nozzle without the need of using a needle for accessing the internal volume of the cartridge. The internal diameter of the lid port is preferably at
20 least 5mm wide, but such diameter may be even wider, e.g. it may be substantially equal to the diameter of the lid base **87b**.

 The ridges **181** of base **87a** surround a central annular recess **85a** formed around the opening **183a** from which the cup port **86a** protrudes. The ridges that closely surround the opening **183a** comprise projections **184** that
25 radially extend towards the center of the opening **183a** and that are as thick as the ridges **181** themselves. The projections **184** act both as a support for the cake of particulate substance and the filtering means and as a fluid flow hurdle for breaking direct fluid flow.

 The cartridge **81** further comprises a rubber pad **186**, which is
30 installed between the projections **184** and the annular recess **85a** and which

comprises a central through slit. The rubber pad **186** is a valve means as intended above.

The cup port **86a** advantageously comprises a fluid flow hurdle **187**, which is a separate piece that is inserted into the cup port and is tightly engaged with the internal surface of the cup port. Providing a separate fluid flow hurdle and eliminating the hurdles directly formed on the internal surface of a port is an advantageous arrangement that is particularly suited for the so-called sequential moulding manufacturing techniques.

The "separate" hurdle **187** preferably comprises a small plastic hollow tube **188** whose open ends are closed with a fluid permissive filter material, for instance a film of plastic sieve material or open mazed tissue/paper. Alternatively, internal barriers can be formed on the internal surface of the tube **188**, which are substantially similar to barriers **114**, **117a** and **117b** described above.

In the embodiment depicted in Figure 27, the tube **188** comprises an upper sieve film **185b** and a bottom sieve film **185a**. In order to fix the hurdle **187** to the inner surface of cup port **86a**, the tube **188** comprises an annular rib **189a** on its outer sidewall for snap-fitting with a corresponding annular recess **189b** formed around the inner surface of the cup port **86a**. Obviously, many other arrangements for fixing a separate hurdle means to the cup port or the lid port are clearly in the reach of the skilled in the art.

With reference to Figures 12-15, a cartridge or capsule **51** according to a further embodiment of the invention comprises a cup portion **52** having a closed base **57** and a peripheral flange **59a** on its mouth. A substantially flat lid portion **53** is fixedly attached to the cup portion **52**, for instance by axially hot welding the peripheral edge **59b** of the lid portion **53** to the flange **59a**. Obviously, any other known joining technique can be provided in the alternative for fixedly attaching the lid portion to the cup portion, such as ultrasonic welding, bonding or combinations of these with forging or deforming techniques.

The lid portion **53** comprises a normally closed lid port **56b** having an M-like cross section and further comprises bulges **151a** and **151b**, for creating a small gap between the lid portion and a dose of ground coffee **54** filling the capsule **51** and sandwiched between filtering means, such as filter paper sheets.

The base **57** and the dose of ground coffee form a substantially conical hollow volume in which a tappet **159** is housed. The tappet is herein defined as a piercing member of a substantially hard material such as plastics having a sort of spike **156** protruding out from a supporting portion **157** of the tappet.

The tappet **159** is arranged inside the above mentioned conical hollow volume so that the tappet **159** normally holds on the cup port **56a** by means of the spike **156**, as shown in Figure 13.

In the preferred embodiment, the supporting portion **157** of the tappet is a disc extending throughout the bottom surface of the dose of ground coffee, which disc comprises a plurality of through holes **55** evenly distributed on its top surface. Furthermore, the bottom side of tappet **159** preferably comprises radial ribs **154**, **158**.

In the preferred embodiment depicted in Figure 15, the tappet **156** comprises surface grooves **155** running along a longitudinal direction from the tip end of the spike towards the bottom surface of the disc **157**, so that the spike **156** resembles the tip end of a Philips screwdriver. Obviously, this shape is only optional and other alternative shapes can be provided for the spike **156**, as long as these shapes allow the tappet to pierce the base **57** of the capsule.

At the beginning of the beverage extraction phase, when the filter holder is inserted into the bayonet holder, a mechanical pressure is applied to the base **57**, which tends to warp towards the tappet. As a consequence, the cup port **56a** is pierced by the spike **156** and an outlet for the extracted beverage is thus automatically created. A gap for conveying the extracted

beverage to the outside is maintained by the ribs **154**, **158** and by the grooves **155**.

The lid port **56b** is instead pierced by the injection nozzle of the extraction machine and the injected water is spread over the top surface of the ground coffee by means of the surface shape of the lid portion **53**.

The capsule **51** is preferably manufactured by thermoforming, starting from a film or sheet of polylaminate thermoplastic or thermoset plastic materials, for instance a multilayer sheet comprising PE, PET and PVDC. With this manufacturing technique, the resulting capsule is very light and handy and uses a modest amount of packaging materials, too.

It is thus seen that even capsule **51** integrates most of features of standard extraction chambers and, as well as the other cartridges according to the invention, it ensures an air-tight preservation of the ground coffee.

Moreover, during the extraction phase, a spout is automatically formed at the cup port **56a**, by means of which the extracted beverage is delivered directly to an external drinking cup or glass without contaminating the cartridge or filter holder.

Various embodiments of the cartridge according to the invention have been described hereinabove. According to a second aspect of the invention, an extraction assembly for application to standard espresso coffee machine or to another machine which can pump hot water or other infusion fluids under pressure for producing beverages will be now described in detail.

With reference to Figures 16-18, an extraction assembly **60** according to a preferred embodiment of the invention comprises a support connectable to an espresso coffee machine, which is preferably composed of a connector member **62**, for connecting the extraction assembly to the water injection tube of the beverage extraction machine, and a bayonet holder **63**.

The connector member **62** has a base and a cylindrical sidewall raising from the base and ending with a flanged rim that serves for mounting

the support on the extraction machine (not shown), for instance by using screws. The base of the connector member **62** comprises a protruding inlet port **65** connectable to the water outlet of the extraction machine and, on the opposite side of the base, a circular guiding wall **259**, which is described
5 hereinafter.

The bayonet holder **63** has a substantially cylindrical shape and comprises an upper open end into which the cylindrical sidewall of connector member **62** fits. Preferably, the bayonet holder **63** is fixed to the connector member **62** by means of the same screws used for mounting the
10 connector member to the extraction machine. Obviously, the bayonet holder and the connector member may be reciprocally fixed in any other known way; for instance, the outer surface of the cylindrical sidewall of the connector member and the upper inner surface of the cylindrical sidewall of the bayonet holder may be threaded. Alternatively, the connector member
15 and the bayonet holder may be built as a single piece.

The bayonet holder **63** further comprises a bottom open end on which guides **263** of a known kind are provided for bayonet fitting with a cartridge holder **64**, which is provided with a grip handle **61**.

The cartridge holder **64** comprises a substantially cylindrical body
20 that is internally shaped so as to completely house the cartridge **21**. In particular, it comprises a cylindrical sidewall that is complementary to the sidewall **28** of the cartridge.

Moreover, the base of the cartridge holder **64** comprises an annular groove **261**, into which the flange **125a** of the cartridge fits slidingly, and a
25 bottom **250**, which is located inside the cylindrical body of the cartridge holder and comprises an opening **267** at its central region.

The depth of the annular groove **261** is substantially equal to the height of the flange **125a**, so that when cartridge **21** is inserted into the cartridge holder **64**, the surface of the base **27** leans almost completely
30 against the bottom **250** and the cup port **26a** protrudes from the opening **267**.

The extraction assembly **60** further comprises an injection nozzle assembly **265a**, **265b** that is firmly mounted on the bottom open end of the inlet **65** facing the cartridge holder, for instance by a thread fitting. Alternatively, the nozzle assembly and the water inlet port **65** may be made
5 in a single piece.

With reference to Figures 21 and 22, the nozzle assembly comprises a hollow nozzle body **265a** and a piercing member or needle **265b** fixedly mounted to the inner surface of the nozzle body. More in detail, the nozzle body is substantially tubular and comprises two open ends **251** and **254**.

10 The open end **254** is located at the bottom end of the nozzle body and it is wide enough to receive a projecting lid port of a cartridge according to the invention, for instance lid port **26b**.

The open end **251** is defined at the upper end of the nozzle body by the wall **253**, which is shaped so as to tightly fit with the inner surface of the
15 bottom open end of the inlet **65**. The external surface of the upper wall **253** and the internal surface of the inlet **65** may be threaded so as to secure the nozzle body to the connector member **62**. Alternative arrangements for coupling the nozzle assembly to the inlet of the connector member may be also provided, as long as a fluid tight fit is guaranteed between them.

20 The external surface of the nozzle body **265a** comprises a radially protruding stepped portion **257** for limiting the axial displacement of a cartridge ejector **269**, as described below. The internal surface of nozzle body **265a**, instead, comprises an annular projection **252** that extends inwardly and which is preferably located in a middle region of the internal
25 surface of the nozzle body.

The needle **265b** is axially inserted and secured in the opening defined by annular projection **252**. In order to allow passage of fluid from the upper open end **251** to the bottom open end **254**, through openings **256** are provided in the annular projection **252**.

30 The internal surface of the nozzle body **265a** further comprises an

annular recess **255**, which is located in a bottom region of the same internal surface, preferably around the bottom open end **254**. Such recess houses an O-ring **266**, which acts as a means for providing a radial fluid-tight seal between the nozzle assembly and the inlet port **26b** of the cartridge **21** during
5 the beverage extraction phase.

A great advantage brought about by the O-ring **266** is that it prevents the injected water from contaminating any internal component or surface of the extraction assembly **60** and from lapping the outer surface of the cartridge, which has to be touched and handled by the user. Accordingly,
10 superior hygienic conditions are guaranteed and the extraction machine can be used hundreds of times without having to clean the components of the extraction assembly, such as the cartridge holder **64** and the support **62**, **63**.

Such a contamination-free arrangement also advantageously combines with the integration of an outlet spout in the cartridge according to
15 the invention. The same beverage extraction machine and the same extraction assembly can be consecutively used for cartridges containing different edible substances, such as coffee, chocolate, tea or herbal infusions, soups, other hot milk beverages, without incorporating the main disadvantage of common systems that contaminate and negatively influence
20 the extraction results of consecutive beverage extractions.

Moreover, the resilient nature of the O-ring **266** allows to use various cartridges having inlet ports of different radial sizes, as long as these radial sized do not exceed the average diameter of the bottom opening **254** of the nozzle assembly.

25 In order to enhance the practicality of the extraction assembly, a cartridge ejector **269** is mounted in the annular space defined by the guiding wall **259** and the portion of the nozzle body **265a** protruding out of the water inlet **65**. The cartridge ejector **269** is substantially toroidal and is preferably shaped so as to fit into the annular space defined by the guiding wall **259**, the
30 base of connector member **62**, the lid portion of the cartridge and the portion

of nozzle body 265a protruding out of the water inlet 65 during the extraction phase.

The cartridge ejector 269 comprises a plurality of springs 268 located in respective hollow housings having an open end from which the springs
5 can extend. The springs 268 abut against the base of the connector member 62 and against respective abutment surfaces provided inside the hollow housings of the cartridge ejector.

When the cartridge holder 64 is fixed to the bayonet holder 63, the ejector 269 is pushed towards the base of the connector member 62 and the
10 springs 268 are compressed. As it is seen in Figure 18, in this position the lid port 26b is pierced by the needle 265b and water can be injected inside the cartridge as described above.

As soon as the cartridge holder is removed, the ejector 269 keeps the cartridge 21 inside the cartridge holder 64, as it is seen from Figure 20. In
15 order to stop the ejector's travel when the cartridge holder is released, an annular projection 258 is provided around the internal surface of the toroidal body of the cartridge ejector, which abuts against the stepped portion 257 of the nozzle body 265a when the ejector slides downwardly towards the cartridge holder.

20 While a particular embodiment of an extraction assembly for an espresso coffee machine has been described with reference to a cartridge of the kind shown in Figure 6, it is understood that any equivalent extraction assembly can be provided that is particularly suited for any cartridge according to the invention.

25 For instance, with reference to Figure 19, a particular extraction assembly 70 suited for a discoidal cartridge 71 according to the invention can be designed, according to the above teachings.

The discoidal cartridge 71 has not been described in detail so far, but it is immediately derivable by combining features of embodiments of the
30 cartridge according to the invention which have already been described in

detail. This combination is hereby presented to show that elements from different embodiments may be combined to obtain further embodiments that clearly fall under the same inventive concept and which are clearly in the reach of the skilled in the art.

5 The cartridge 71 incorporates features of cartridges 11, 31 and 41. In detail, it has a general discoidal shape and houses a coffee tablet of a known kind, as cartridge 31. The cup portion of cartridge 71 is similar to the cup portion 37, but comprises a shim 119 and a rubber valve or pad 116 of the kind used in cartridge 11; the pad 116 is depicted in a deformed condition,
10 which is reached during the extraction phase. Differently from cartridge 31, the lid port only slightly protrudes with respect to the lid portion and it is closed by a rubber plug or seal 78, identical to the plug 48 used in cartridge 41.

 Accordingly, the extraction assembly 70 comprises a support
15 connectable to an espresso coffee machine, which is preferably composed of a connector member 72, for connecting the extraction assembly to the water injection tube of the beverage extraction machine, and a bayonet holder 73.

 The connector member 72 comprises a water inlet port 75, for connection to a water injection port of a beverage extraction machine, and a
20 annular wall 359 protruding towards the internal volume of the bayonet holder 73 when this is mounted on the connector member.

 The bayonet holder 73 has a substantially cylindrical shape and comprises an upper open end into which the annular wall 359 of the connector member 72 fits. Preferably, the bayonet holder 73 is fixed to the
25 connector member 72 by means of the same screws used for mounting the connector member to the extraction machine. Obviously, the bayonet holder and the connector member may be reciprocally fixed in any other known way; for instance, the outer surface of the cylindrical sidewall of the connector member and the upper inner surface of the cylindrical sidewall of
30 the bayonet holder may be threaded. Alternatively, the connector member

and the bayonet holder may be built in a single piece.

The bayonet holder 73 further comprises a bottom open end on which guides 263 of a known kind are provided for bayonet fitting with a cartridge holder 74.

5 The cartridge holder 74 comprises a substantially flattened body whose internal shape is complementary to the cup portion of cartridge 71. Moreover, the base of the cartridge holder 74 comprises an opening 377 at its central region through which a cup port 76a of cartridge 71 is arranged.

When the cartridge holder 74 is firmly secured to the bayonet holder
10 73, the peripheral flat rim 79 of cartridge 71 is tightly kept between the annular wall 359 and the rim of cartridge holder 74.

The extraction assembly further comprises a nozzle 275 that is secured to the inlet port 75 and that protrudes towards the cartridge holder.

Referring to Figure 23, the nozzle 275 is a substantially cylindrical
15 hollow piece having an inner axial cavity 359 for receiving water from the water inlet 75 and having a needle or piercing member 358 integrated therein. The cavity 359 extends as far as the needle, which is axially hollow and comprises radial through openings 356 for supplying water in a substantially radial direction.

20 An annular recess 355 is further provided in the nozzle 275, in particular around the needle 358. The recess 355 is shaped so as to receive the thicker peripheral portion of the plug 78 as soon as the cartridge holder 74 is secured to the bayonet holder 73. As it is noted from Figure 19, in this position the plug 78 is pierced by the needle 358, so that water can be
25 injected inside the cartridge, and the plug 78 provides for a fluid-tight seal between the nozzle 275 and the lid port of cartridge 71.

Therefore, the plug 78 acts as a means for providing radial fluid-tight seal between the water inlet port of the extraction assembly and the cartridge, thus preventing the injected water from lapping the external surface of the
30 cartridge.

Advantageously, the extraction assembly **70** comprises a cartridge ejector **369** that is housed in the annular space defined by the wall **359** and the nozzle **275** and that is similar to the ejector **269**.

When the cartridge holder **74** is fixed to the bayonet holder **73**, the
5 ejector **369** is pushed upwardly towards the connector member **72** by means of springs **368**, which are accordingly compressed. Instead, when the cartridge holder **74** is removed from the bayonet holder **73**, the ejector **269** keeps the cartridge **71** inside the cartridge holder **74**. In order to stop the ejector's travel when the cartridge holder is released, an annular projection
10 **378** is provided around the internal surface of the toroidal body of the cartridge ejector **369**, which abuts against the stepped portion **357** of the nozzle body **275** when the ejector slides downwards towards the cartridge holder.

With reference to Figures 24-26, an extraction assembly **80** according
15 to yet another embodiment of the invention comprises a support connectable to an espresso coffee machine, which is preferably composed of a connector member **82**, for connecting the extraction assembly to the water injection tube of the beverage extraction machine, and a bayonet holder **83**.

The connector member **82** has a base and a cylindrical sidewall
20 raising from the base and ending with a flanged rim that serves for mounting the support on the extraction machine (not shown), for instance by using screws. The base of the connector member **82** comprises a protruding inlet port **85** connectable to the water outlet of the extraction machine and, on the opposite side of the base, a circular guiding wall **459**. It is seen that the
25 connector member **82** is substantially similar to the previously described connector member **62**.

The bayonet holder **83** has a substantially cylindrical shape and comprises an upper open end into which the cylindrical sidewall of connector member **82** fits. Preferably, the bayonet holder **83** is fixed to the
30 connector member **82** by means of the same screws used for mounting the

connector member to the extraction machine. Obviously, the bayonet holder and the connector member may be reciprocally fixed in any other known way. For instance, the outer surface of the cylindrical sidewall of the connector member and the upper inner surface of the cylindrical sidewall of the bayonet holder may be threaded. Alternatively, the connector member and the bayonet holder may be built as a single piece.

Moreover, the bayonet holder **83** comprises a bottom open end on which guides of a known kind are provided for bayonet fitting with a cartridge holder **84**.

10 In order to deliver water inside the cartridge **51**, a nozzle **285** is secured to the inlet port **85** and protrudes towards the cartridge holder **84**.

Referring to Figure 26, the nozzle **285** is a substantially cylindrical hollow piece in which an inner axial cavity **459** is formed for receiving water from the water inlet **85**. A hollow needle or piercing member **458** is integrated with the nozzle **285** so that the cavity **459** extends as far as the needle. Advantageously, the needle **458** comprises radial through openings **456** for supplying water in a substantially radial direction.

An annular recess **455** is further provided in the nozzle **285**, in particular around the needle **458**, for housing an O-ring **466**, which acts as a means for providing a radial fluid-tight seal between the nozzle assembly and the inlet port **56b** of the cartridge **51** during the beverage extraction phase.

Advantageously, the extraction assembly **80** comprises a cartridge ejector **469** that is housed in the annular space defined by the wall **459** and the nozzle **285** and that is similar to the ejector **269**.

The ejector **469** preferably comprises a peripheral annular rib **470** on its bottom side, which is shaped so as to engage the peripheral bulge **151a** of the lid portion of cartridge **51** when the cartridge holder is secured to the bayonet holder.

30 The cartridge holder **84** has a substantially cylindrical body that is

internally shaped so as to house capsule **51**. In particular, it comprises an inner sidewall that is shaped substantially complementary to the sidewall of the capsule and that ends with an annular shoulder **86** in an upper region and with an opening **477** in a bottom region of the capsule holder.

5 The base of the cartridge holder **84** has not the same slope of the base **57** of capsule **51**. Preferably, the base region of the capsule holder **84** slopes substantially parallel to the ribs **154** and **158** of the tappet **159**. Accordingly, in an initial condition in which the cartridge holder is not completely secured to the bayonet holder, the capsule **51** supports itself on the contour of the
10 opening **477** only in correspondence of the region around the cup port **56a** and the flanges **59a**, **59b** are in a raised position with respect to the annular shoulder **86** of the cartridge holder **84**.

As soon as the cartridge holder **84** is manually rotated for securing it to the bayonet holder **83**, the lid portion of the capsule **51** firstly abuts
15 against the bottom surface of the ejector **469** and then abuts against the annular wall **459**. Accordingly, a pressure is applied to the base **57** that causes the spike **156** to pierce the cup port **56a** and the base **57** to buckle against the bottom side of tappet **159**.

In the final position, that is to say in the position shown in Figure 25
20 in which the capsule holder **84** is fully secured to the bayonet holder **83** and the system is ready for the beverage extraction phase, the cup port **56a** is fully opened and the extracted beverage can be supplied directly in an external cup.

Figure 25 also shows that, in the beverage extraction position, the
25 nozzle **285** has pierced the inlet port **56b** of capsule **51**. The M-like shape of the inlet port **56b** advantageously provides for an easy engagement with the needle portion of the nozzle **285**.

Advantageously, as soon as the capsule holder **84** is removed from the bayonet holder, the ejector **469** keeps cartridge **51** inside the cartridge
30 holder **84**. In order to stop the ejector's travel when the cartridge holder is

released, an annular projection 478 is provided around the internal surface of the toroidal body of the cartridge ejector, which stops against an abutment 57 of the nozzle body 285 when the ejector slides downwards.

The above extraction assemblies comprise an injection nozzle that is
5 provided with a needle for breaking the plug or seal of the upper port of the cartridge and for accessing the internal volume of the cartridge. Moreover, the upper ports of the above cartridges are sized so as to be insertable into a corresponding female nozzle. However, it is possible to provide an opposite coupling between the injection nozzle and the upper port of a cartridge
10 without departing from the scope of the present invention. For instance, with reference to Figure 28, an extraction assembly according to another embodiment of the invention comprises a support connectable to an espresso coffee machine, which is preferably composed of a connector member 582, for connecting the extraction assembly to the water injection tube of the
15 beverage extraction machine, and a bayonet holder 583.

The connector member 582 has a base and a cylindrical sidewall raising from the base and ending with a flanged rim that serves for mounting the support on the extraction machine (not shown), for instance by using screws. The base of the connector member 582 comprises a protruding inlet
20 port 585 connectable to the water outlet of the extraction machine and, on the opposite side of the base, a circular guiding wall 559.

The bayonet holder 583 has a substantially cylindrical shape and comprises an upper open end into which the connector member 582 fits. Preferably, the bayonet holder 583 is fixed to the connector member 582 by
25 means of the same screws used for mounting the connector member to the extraction machine, as in the embodiments described here above. Obviously, the bayonet holder and the connector member may be reciprocally fixed in any other known way; for instance, the outer surface of the cylindrical sidewall of the connector member and the upper inner surface of the
30 cylindrical sidewall of the bayonet holder may be threaded. Alternatively, the

connector member and the bayonet holder may be built as a single piece.

The bayonet holder **583** further comprises a bottom open end on which guides of a known kind are provided for bayonet fitting with a cartridge holder **584**.

5 The cartridge holder **584** comprises a substantially cylindrical body that is internally shaped so as to completely house the above described cartridge **81**. In particular, it comprises a cylindrical inner sidewall that is complementary to the sidewall of the cartridge.

Moreover, the base of the cartridge holder **584** comprises an annular
10 groove **561** into which the lower flange of the cartridge **81** fits slidingly, and a bottom **550** that is located inside the cylindrical body of the cartridge holder and that comprises an opening **567** at its central region. The annular groove **561** and the bottom **550** are shaped so that when the cartridge **81** is inserted into the cartridge holder **584**, the surface of its base **87a** leans almost
15 completely against the bottom **550** and the cup port **86a** protrudes from the opening **567**.

The extraction assembly of Figure 28 further comprises an injection nozzle **575** that is firmly mounted on the bottom open end of the inlet **585** facing the cartridge holder, for instance by a thread fitting. Alternatively, the
20 nozzle assembly and the water inlet port **585** may be made in a single piece.

The nozzle **575** comprises a hollow cylindrical body with opposite open ends and comprises a flange **557** in a middle region thereof.

A hollow tip end **558** of a substantially cylindrical shape protrudes axially from the flange **557** of the nozzle towards the cartridge holder and it
25 is shaped so as to have an external diameter that is generally smaller than the inner diameter of the lid port **86b**. Accordingly, the tip end **558** can be completely inserted into the lid port when the cartridge holder **584** is fixedly mounted on the bayonet holder **583**, thanks to the appositely wide lid port **56b**.

30 The tip end **558** is substantially wider than a (common) injection

needle, but it is small enough to be insertable as a male part into a cartridge port such as the lid port **86b**. Advantageously, the tip end **558** comprises an annular recess formed around its external surface, for housing a sealing means such as an O-ring **566**.

5 Advantageously, the extraction assembly comprises a toroidal cartridge ejector **569**, which is housed in the annular space defined by the wall **559** of the connector member and the nozzle **575** and which is similar to the other cartridge ejectors described here above.

10 The axial travel of the ejector **569** is limited by means of common snap-brackets **578**, which extend upwardly and which are slidably inserted into an appropriate annular recess **579** surrounding the nozzle **575**. The limit stop for the snap-brackets **578** is defined by the flange **557** of the nozzle **575**.

15 Advantageously, the toroidal cartridge ejector **569** comprises an inner concentric sidewall **568** that is sized so as to define an annular gap between the tip end **558** of the injection nozzle, which gap is completely filled with the sidewall of the lid port **86b** when the cartridge **81** is mounted into the extraction assembly. Therefore, in the particular arrangement depicted in Figure 28, the cartridge ejector acts also as a retaining wall against a possible expansion of the lid port during the extraction phase.

20 The extraction assembly of Figure 28 benefits of a simple arrangement that eliminates piercing needles and, at the same time, guarantees a contamination-free coupling between the cartridge, the extraction chamber and the water injection chamber. In fact, regardless of whether the lid port is closed or not before installing it into the extraction
25 assembly, the injection nozzle acts as a male part and the lid port as a female part, and the injection nozzle can pierce the upper seal, if any, of the lid port without the need of an appropriate needle.

30 The injection portion **575**, **585** of the extraction assembly is kept insulated from the extraction chamber defined by the cartridge by means of an external O-ring, and a very high number of consecutive extraction

processes of the same or different beverages can be carried out without cleaning or servicing in any way the extraction assembly.

Moreover, the external O-ring 566 of the injection nozzle can be easily replaced or serviced without having to access internal parts of the
5 injection nozzle itself.

It has thus been shown that the present invention fulfils the proposed aim and objects. Clearly, several modifications to either the cartridges and the extraction assemblies according to the invention will be apparent to and can be readily made by the skilled in the art without departing from the scope
10 of the present invention. Therefore, the scope of the claims shall not be limited by the illustrations or the preferred embodiments given in the description in the form of examples, but rather the claims shall encompass all of the features of patentable novelty that reside in the present invention, including all the features that would be treated as equivalents by the skilled
15 in the art.

Where technical features mentioned in any claim are followed by reference signs, those reference signs have been included for the sole purpose of increasing the intelligibility of the claims and accordingly, such reference signs do not have any limiting effect on the interpretation of each
20 element identified by way of example by such reference signs.

CLAIMS

1. A beverage extraction assembly for application to beverage extraction machines for extracting a beverage from a particulate substance contained in a cartridge, characterized in that it comprises:

5 a support connectable to a water outlet of a beverage extraction machine;

 a cartridge holder removably mounted on said support for holding a cartridge containing a particulate substance, said cartridge comprising at least a first cartridge port protruding outwardly from its upper
10 surface for receiving water under pressure;

 said support comprising a water inlet port connectable to said water outlet of the beverage extraction machine, for delivering said water to said first cartridge port,

 said cartridge holder comprising a bottom aperture for providing
15 an escape for the extracted beverage;

 said water inlet port of said support comprising means for providing a radial fluid-tight seal between said water inlet port and said first cartridge port.

2. The extraction assembly of claim 1, characterized in that it
20 comprises an injection nozzle assembly that is integral or connected to with said water inlet port and that faces the cartridge holder, said injection nozzle assembly being engageable with said first cartridge port so as to inject said water under pressure into said cartridge.

3. The extraction assembly of claim 1, characterized in that said
25 nozzle assembly comprises:

 a hollow nozzle body, having an internal through cavity for allowing passage of water therethrough from a first open end of said nozzle body, which is connected with said water inlet port, to a second open end of said nozzle body, which receives said first cartridge port therein;

30 a needle integral with said nozzle body, for providing an access

to the inside of said first cartridge port.

4. The extraction assembly of claim 3, characterized in that said needle is a separate piece secured into an annular projection formed on said internal through cavity.

5 5. The extraction assembly of claim 3, characterized in that said needle comprises an axial cavity communicating with the internal through cavity of said nozzle body, said needle further comprising radial through openings communicating with said axial cavity for supplying water in a substantially radial direction.

10 6. The extraction assembly of any one of claims 3 to 5, characterized in that said nozzle body comprises an annular recess at said second open end, so as to house said means for providing a radial fluid-tight seal.

7. The extraction assembly of any one of the preceding claims, characterized in that said means for providing a radial fluid-tight seal
15 comprise an O-ring.

8. The extraction assembly of any one of the preceding claims, characterized in that said means for providing a radial fluid-tight seal comprise a rubber gasket having a central pierceable portion and a peripheral thicker portion, said rubber gasket being plugging said first cartridge port
20 before said needle pierces it.

9. The extraction assembly of any one of the preceding claims, characterized in that it comprises a cartridge ejector mounted on said support, for keeping said cartridge pressed inside said cartridge holder until said cartridge holder is at least partially removed from said support.

25 10. The extraction assembly of claim 9, characterized in that said cartridge ejector is substantially toroidal and is mounted around said nozzle assembly, said cartridge ejector comprising spring means abutting its upper surface and a lower surface of said support.

11. The extraction assembly of any one of the preceding claims,
30 characterized in that said support comprises a connector member comprising

said water inlet port and comprises a bayonet holder on which said cartridge holder is securable according to a bayonet fitting.

12. The extraction assembly of any one of the preceding claims, characterized in that said cartridge holder is substantially cup-shaped so as to house said cartridge, the inner surface of said cartridge holder being shaped substantially complementary to the outer shape of said cartridge.

13. The extraction assembly of any one of the preceding claims, characterized in that said bottom aperture of said cartridge holder is large enough to allow a beverage outlet spout integrated in said cartridge to pass through said aperture, in order to prevent said cartridge holder from being contaminated by the extracted beverage output from said cartridge and, accordingly, so that the same beverage extraction machine and the same extraction assembly can be consecutively used over time with cartridges containing different particulate substances.

14. The extraction assembly of any one of the preceding claims, characterized in that said nozzle assembly comprises:

a hollow nozzle body, having an internal through cavity for allowing passage of water therethrough from a first open end of said nozzle body, that is connected with said water inlet port, to a second open end of said nozzle body, that is engageable with said first cartridge port, said hollow nozzle body comprising a tip end at said second open end which is insertable into said first cartridge port, so as to deliver said water under pressure inside said cartridge without using an injection needle.

15. The extraction assembly of claim 14, characterized in that said tip end comprises said means for providing a radial fluid-tight seal which are mounted on its external surface.

16. The extraction assembly of claim 14 or 15 characterized in that said means for providing a radial fluid-tight seal comprise an O-ring installed into an annular recess formed on the external surface of said tip end of said nozzle assembly.

17. The extraction assembly of claim 1, characterized in that said cartridge comprises

5 a main body comprising a cup portion and a lid portion, the cup portion comprising a base, a sidewall and a rim opposed to said base, the lid portion being fixedly attached to said rim of the cup portion so as to define an internal volume of said cartridge,

the internal volume of said cartridge housing the particulate substance comprised within filtering means for retaining said particulate substance and for percolating fluid substances therethrough,

10 said lid portion comprising said cartridge port defining an inlet passage for said water,

a tappet being arranged inside a conical hollow volume defined between said filtering means and said base, so as to pierce said base when a pressure is applied to said base towards said internal volume, thus opening a
15 normally closed cup port and forming a spout,

wherein said cartridge holder is internally shaped so as to apply said pressure to the base of said cartridge towards said internal volume when the cartridge holder is secured to said support.

26. März 2004

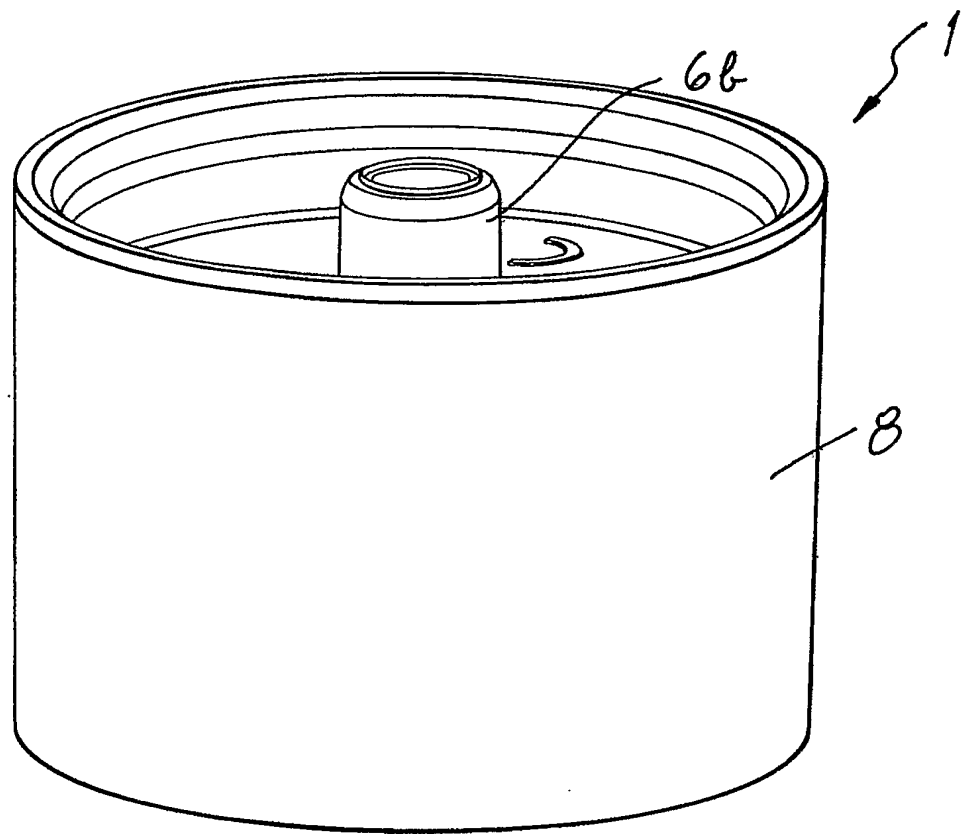
BEVERAGE EXTRACTION ASSEMBLY FOR EXTRACTING A
BEVERAGE FROM A PARTICULATE SUBSTANCE CONTAINED IN A
CARTRIDGE

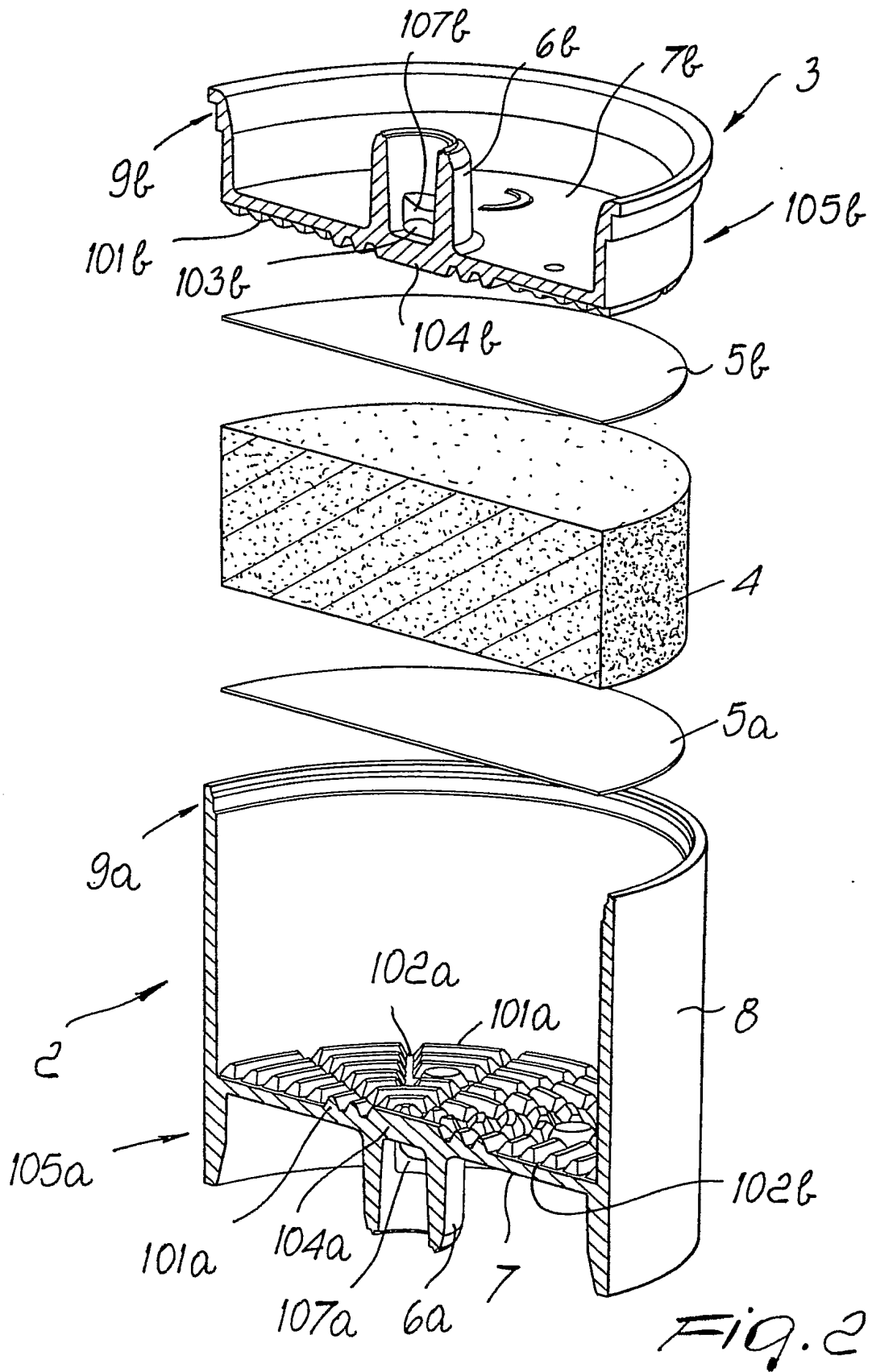
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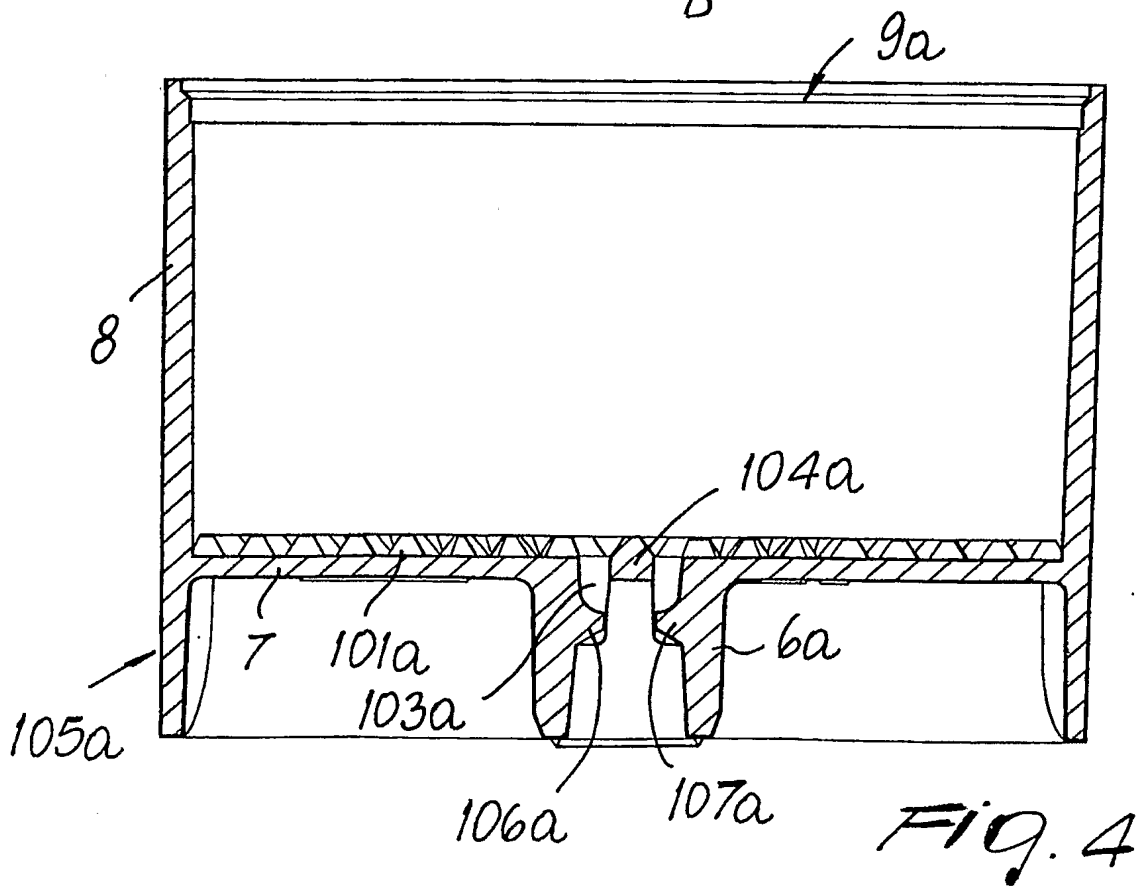
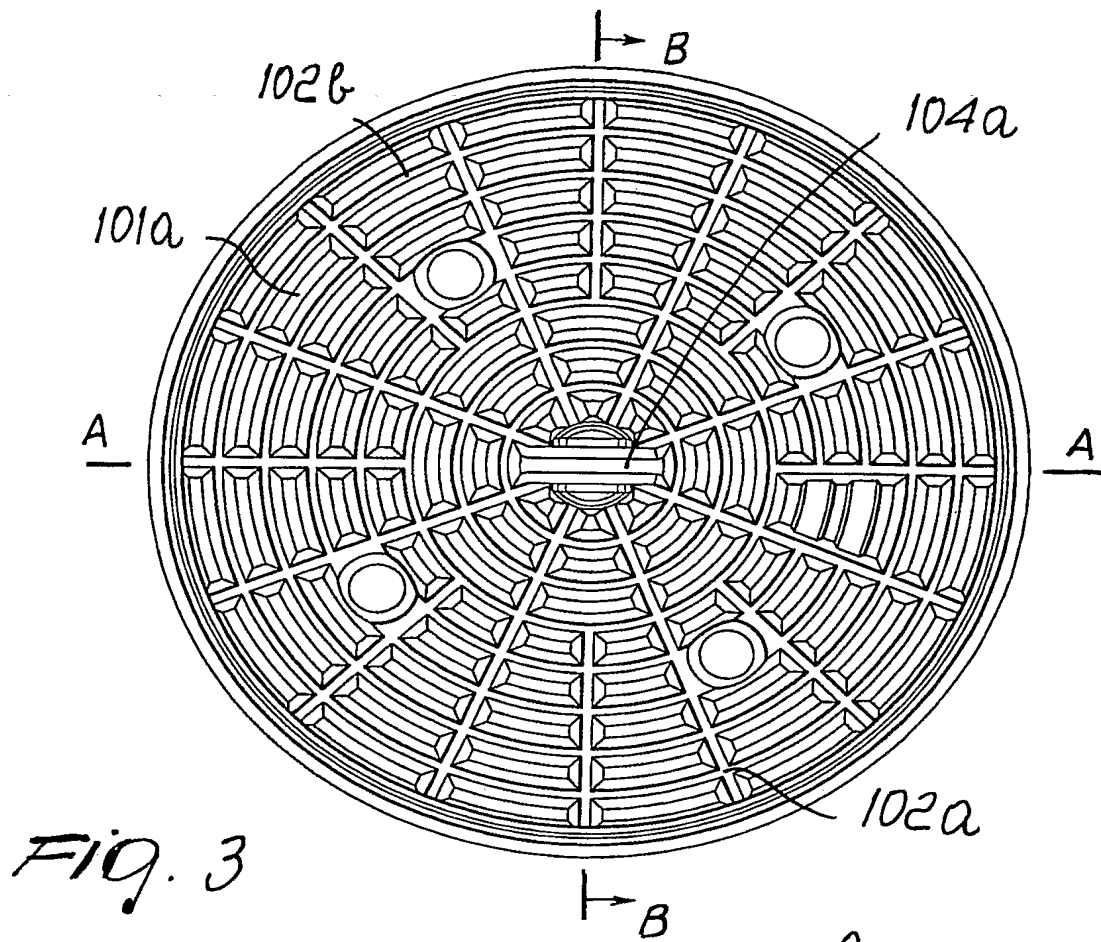
ABSTRACT OF THE DISCLOSURE

A beverage extraction assembly (60) for application to beverage
extraction machines for extracting a beverage from a particulate substance
contained in a cartridge, characterized in that it comprises: a support(62,63)
10 connectable to a water outlet of a beverage extraction machine; a cartridge
holder (64) removably mounted on the support (62,63) for holding a
cartridge (21) containing a particulate substance, the cartridge (21)
comprising at least a first cartridge port (26b) protruding outwardly from its
upper surface for receiving water under pressure; the support (62,63)
15 comprising a water inlet port (65) connectable to the water outlet, for
delivering the water to the first cartridge port (26b), the cartridge holder (64)
comprising a bottom aperture (267) for providing an escape for the extracted
beverage; the water inlet port (65) of the support (62,63) comprising means
(266) for providing a radial fluid-tight seal between the water inlet port (65)
20 and the first cartridge port (26b).

(Figure 18)

*Fig. 1*





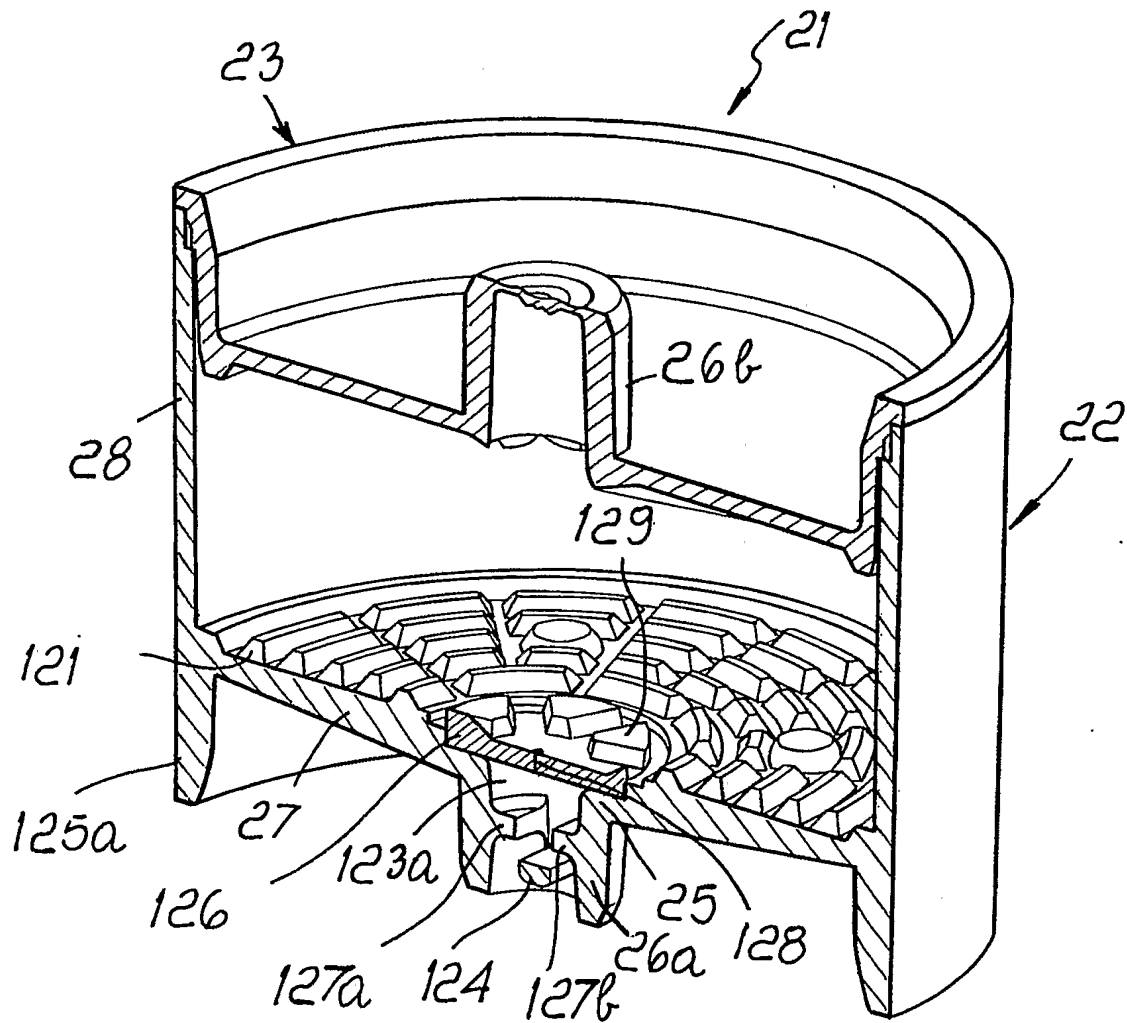


Fig. 6

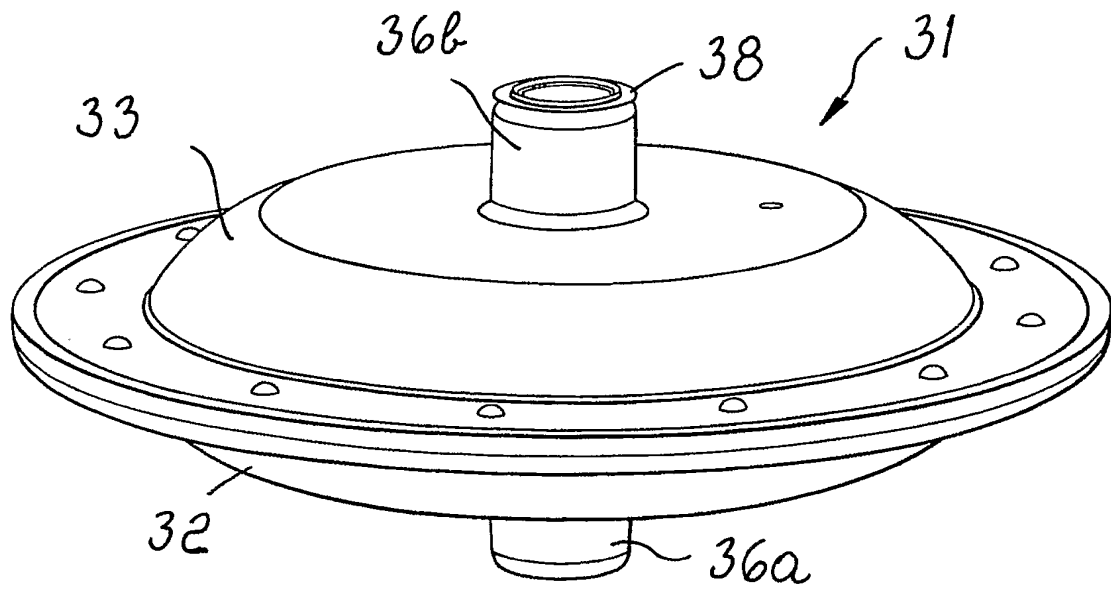
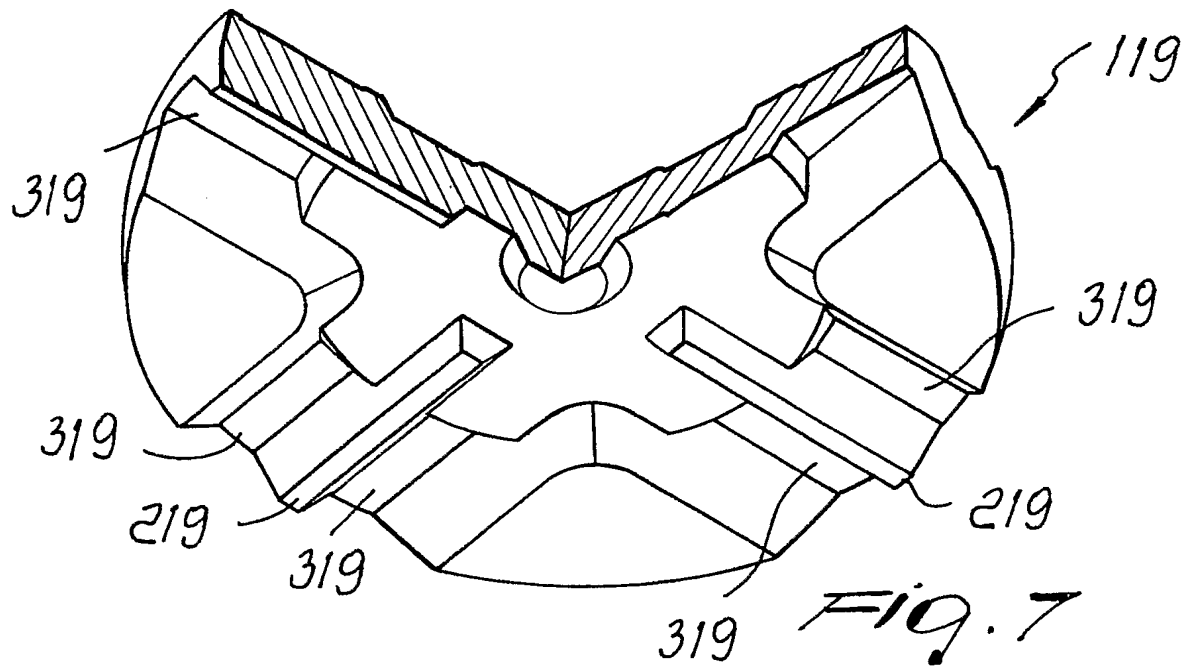
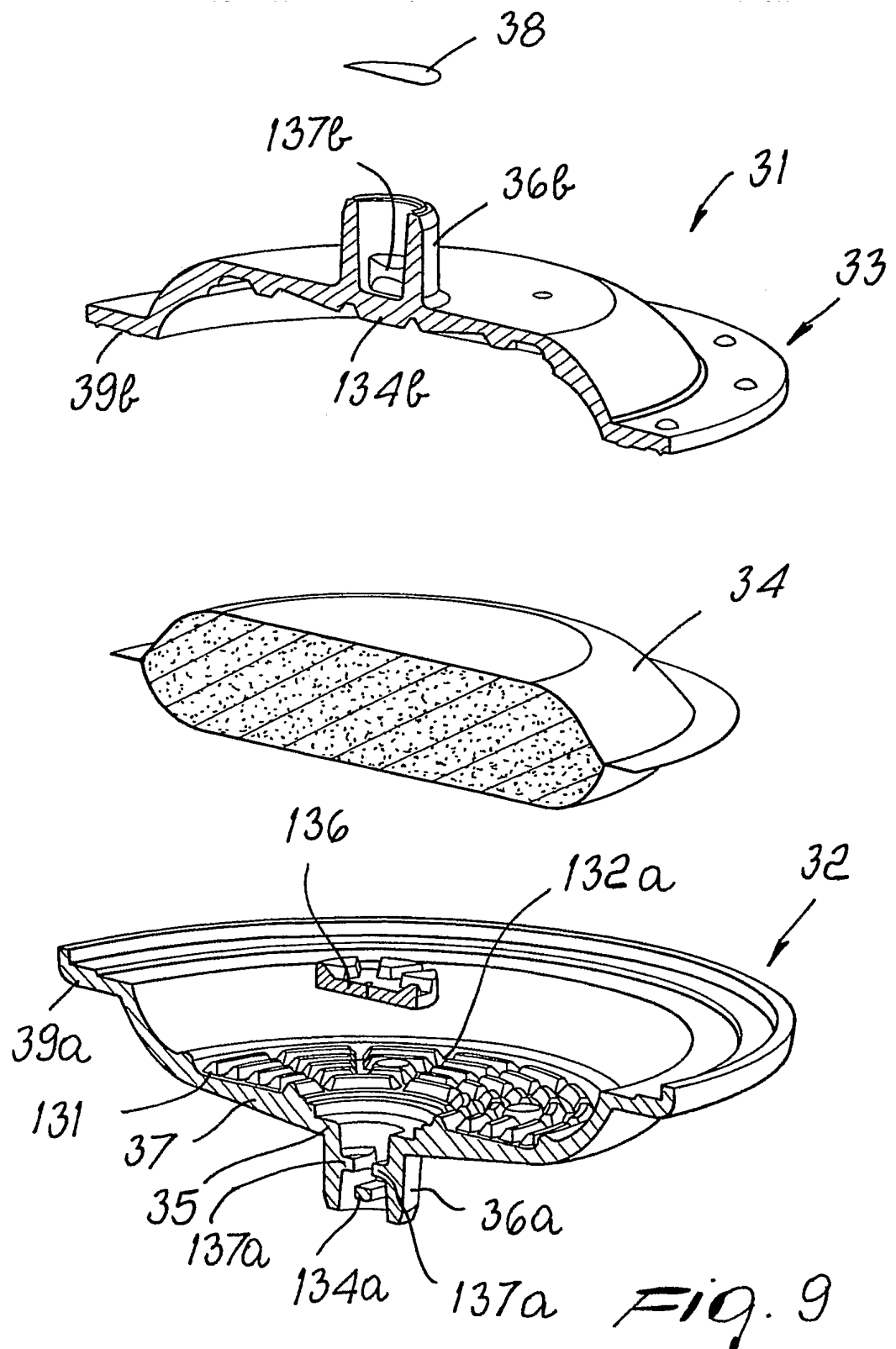
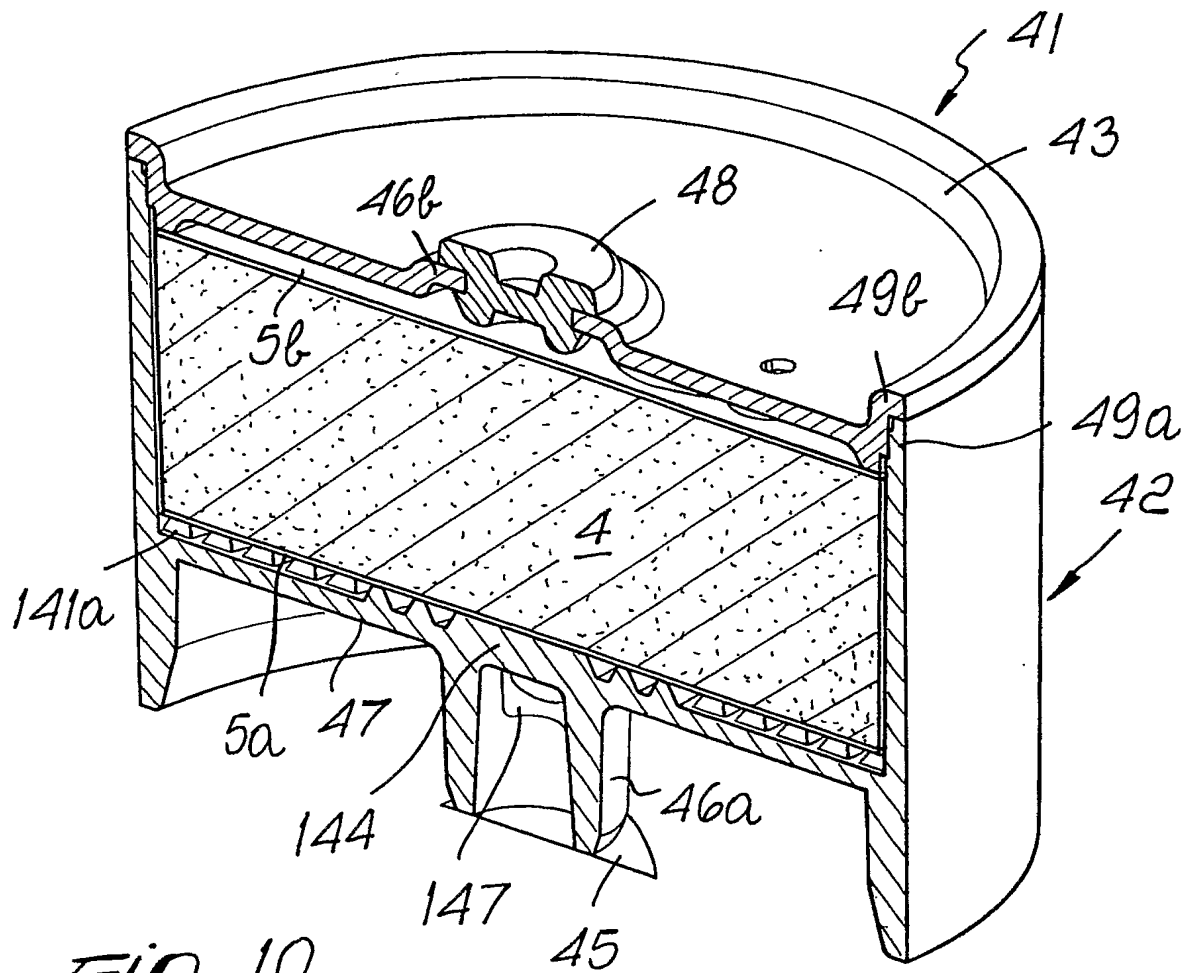
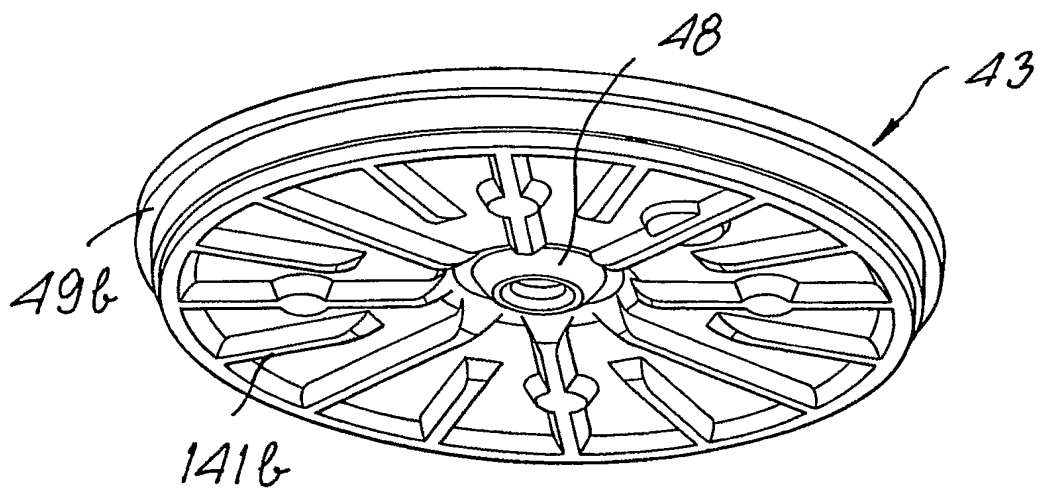


Fig. 8



*Fig. 10**Fig. 11*

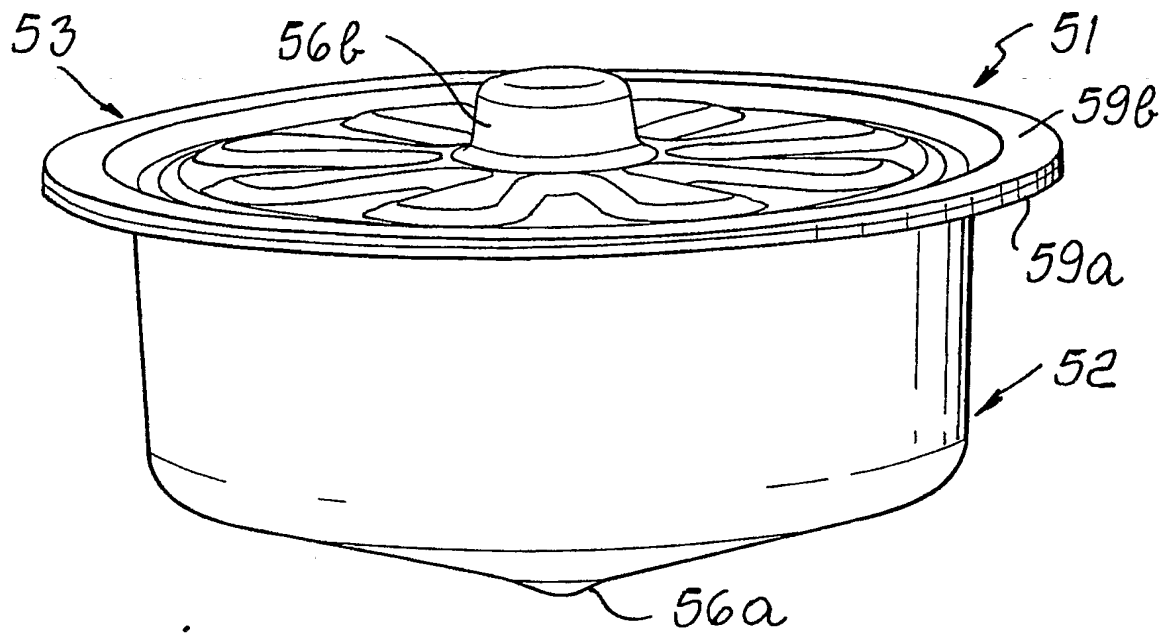


FIG. 12

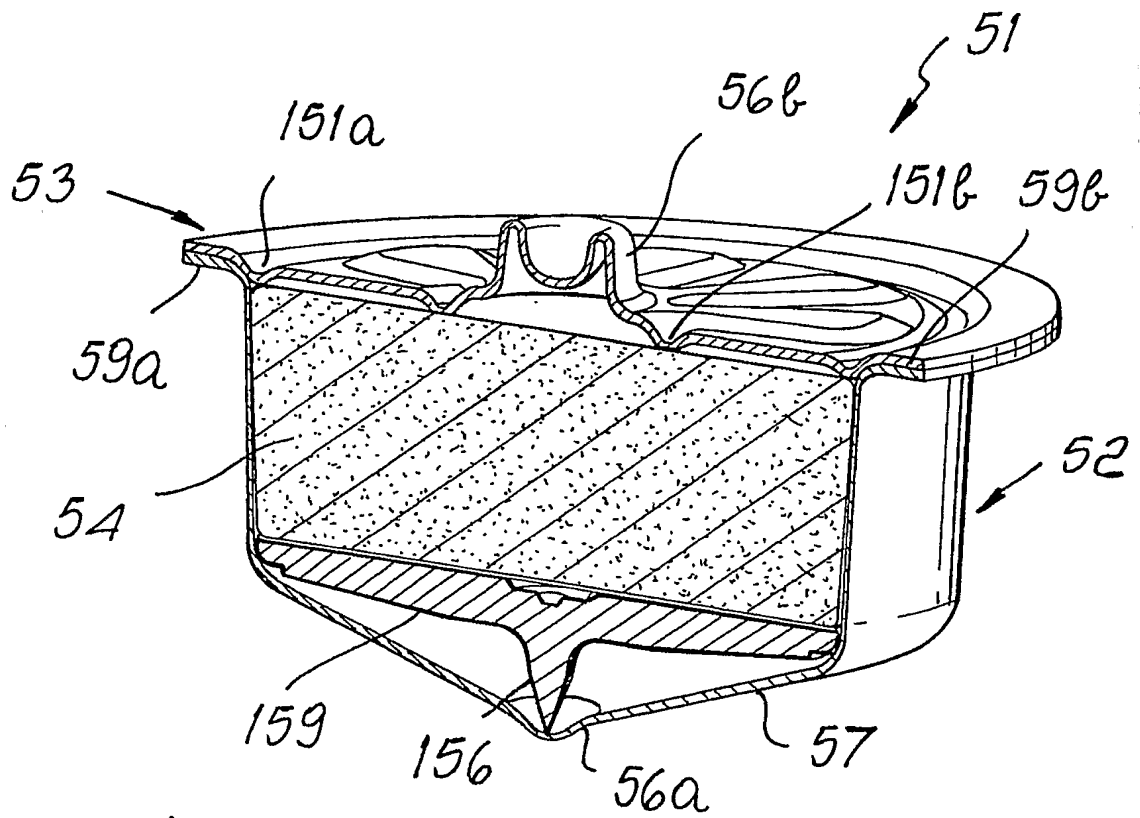
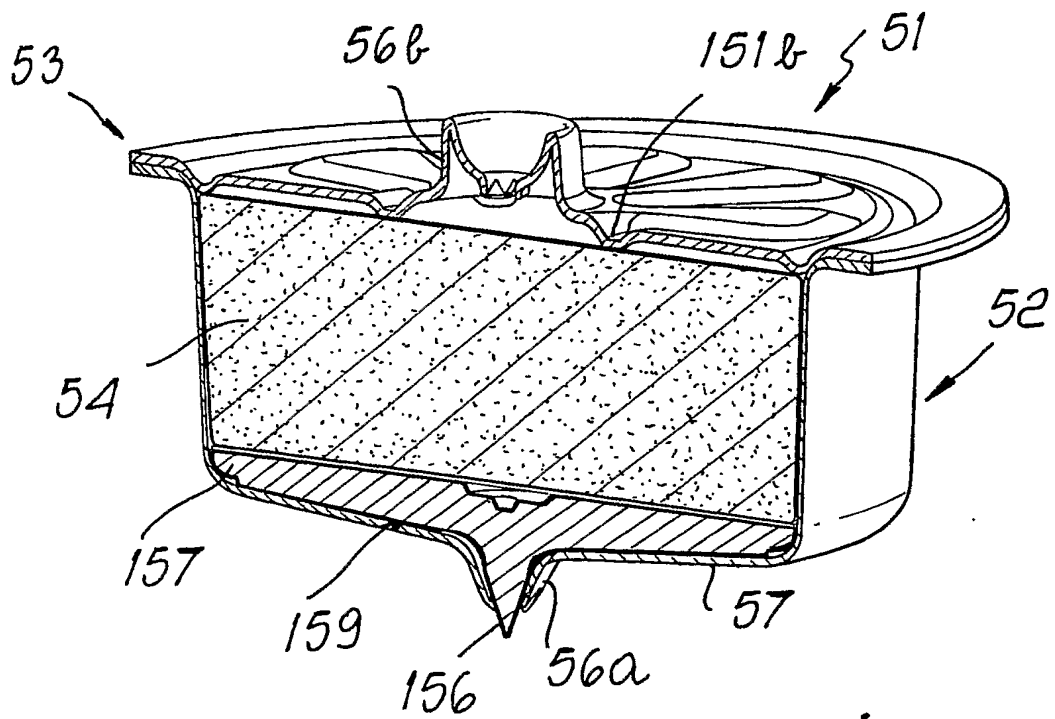
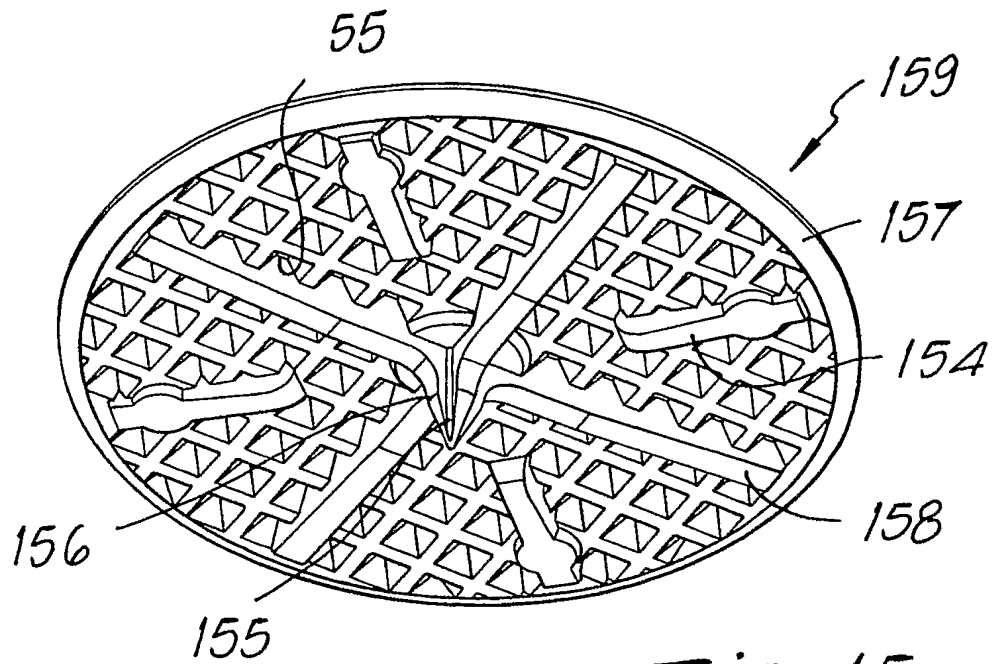


FIG. 13

*Fig. 14**Fig. 15*

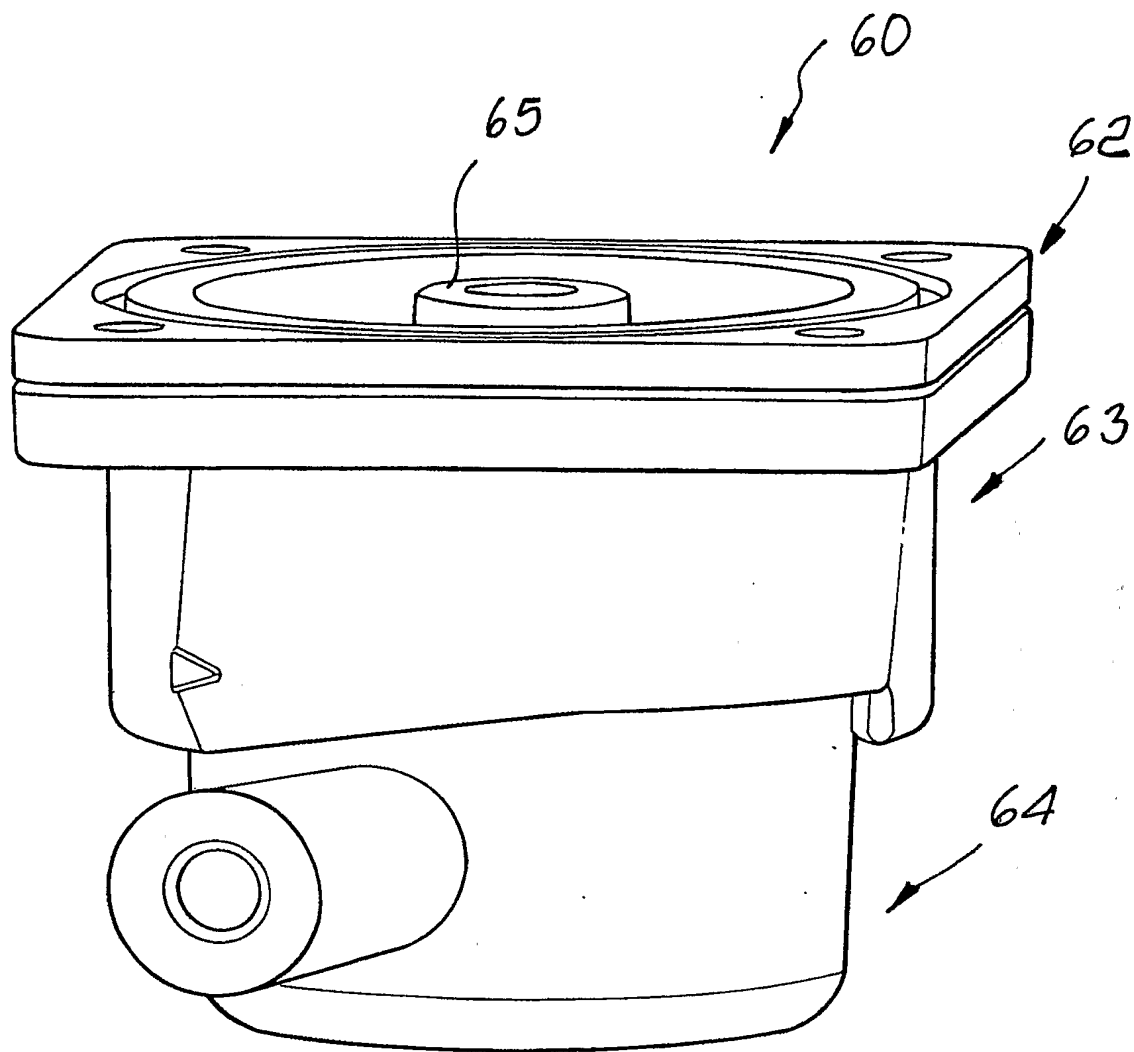


Fig. 16

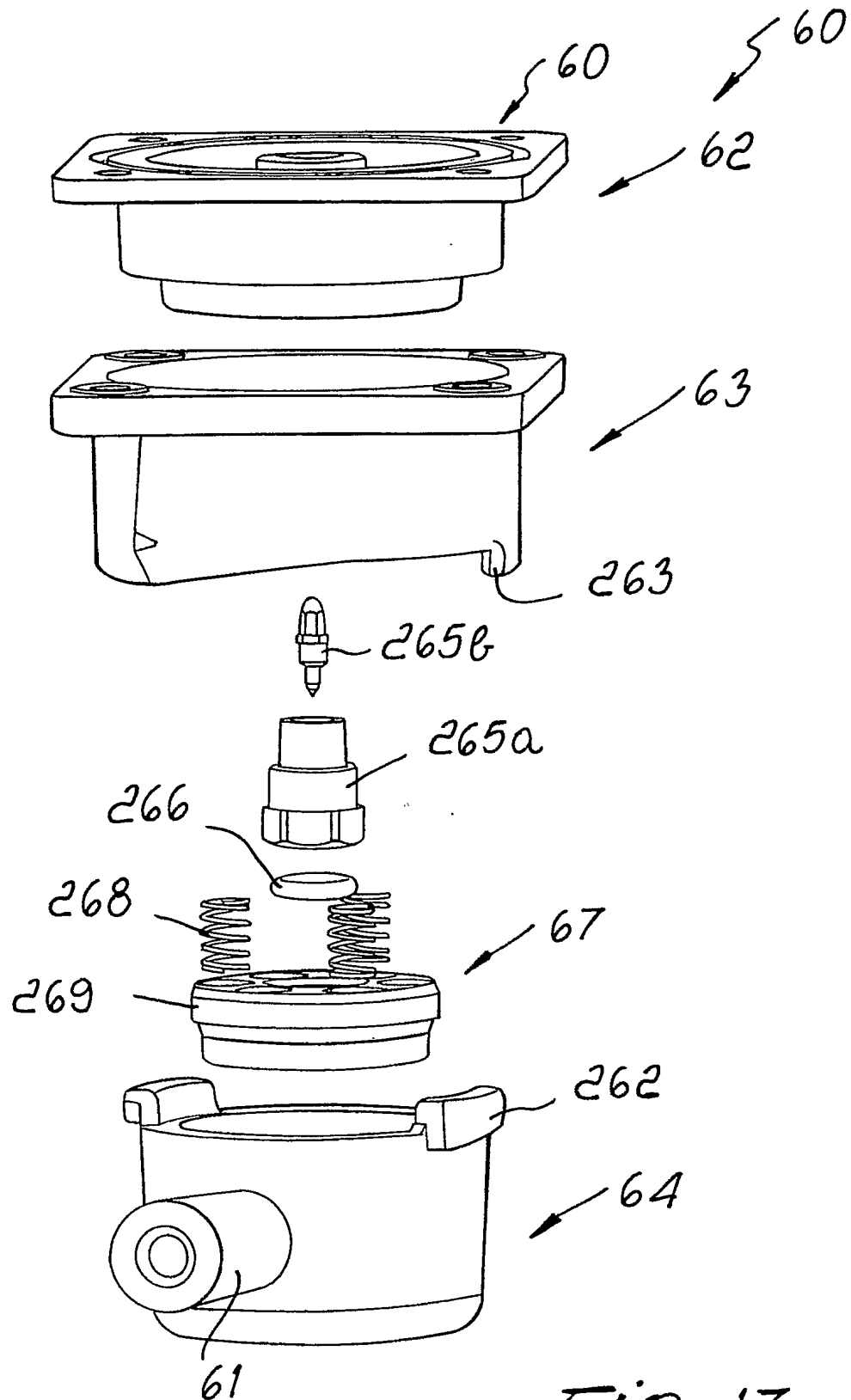
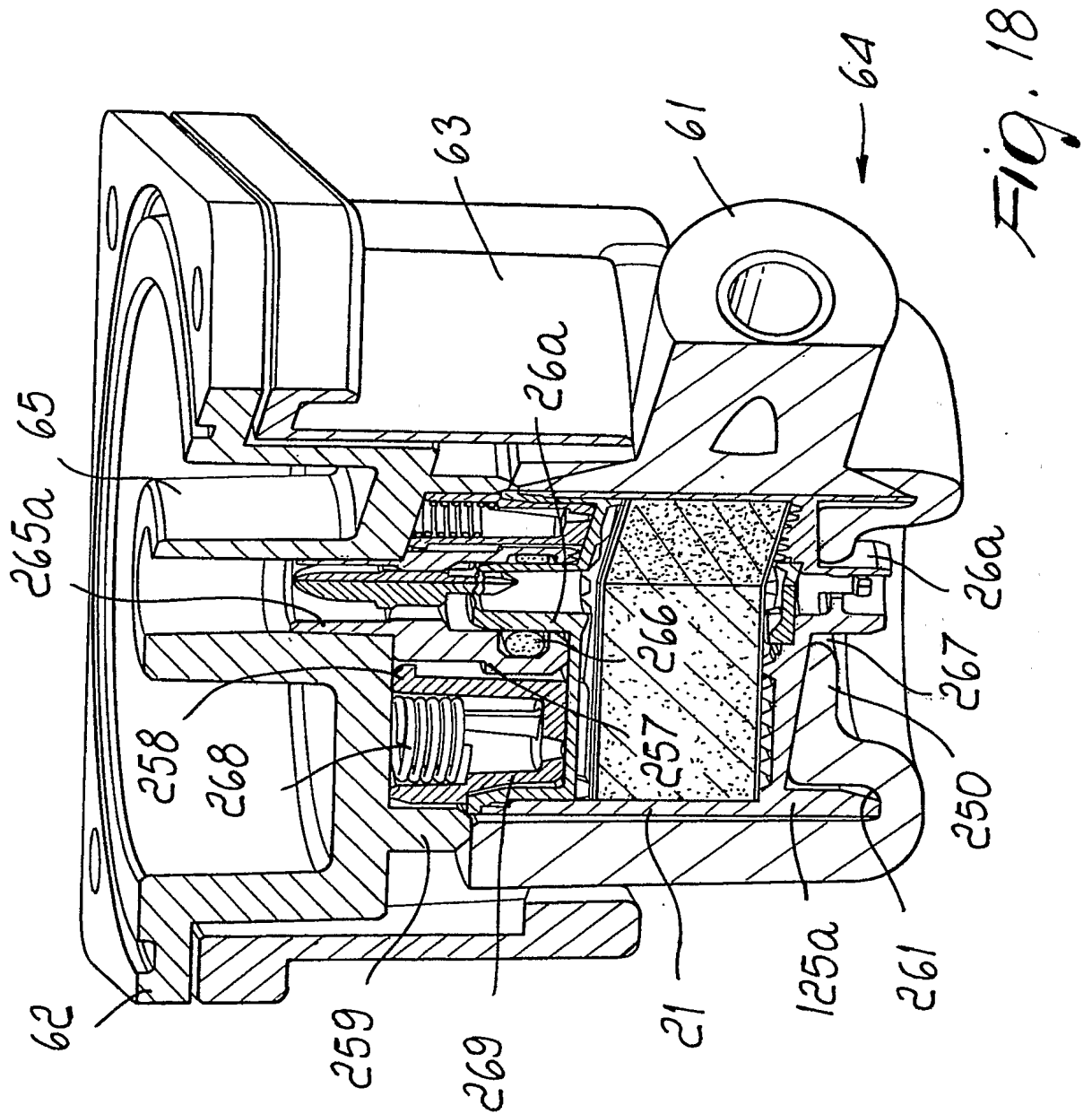
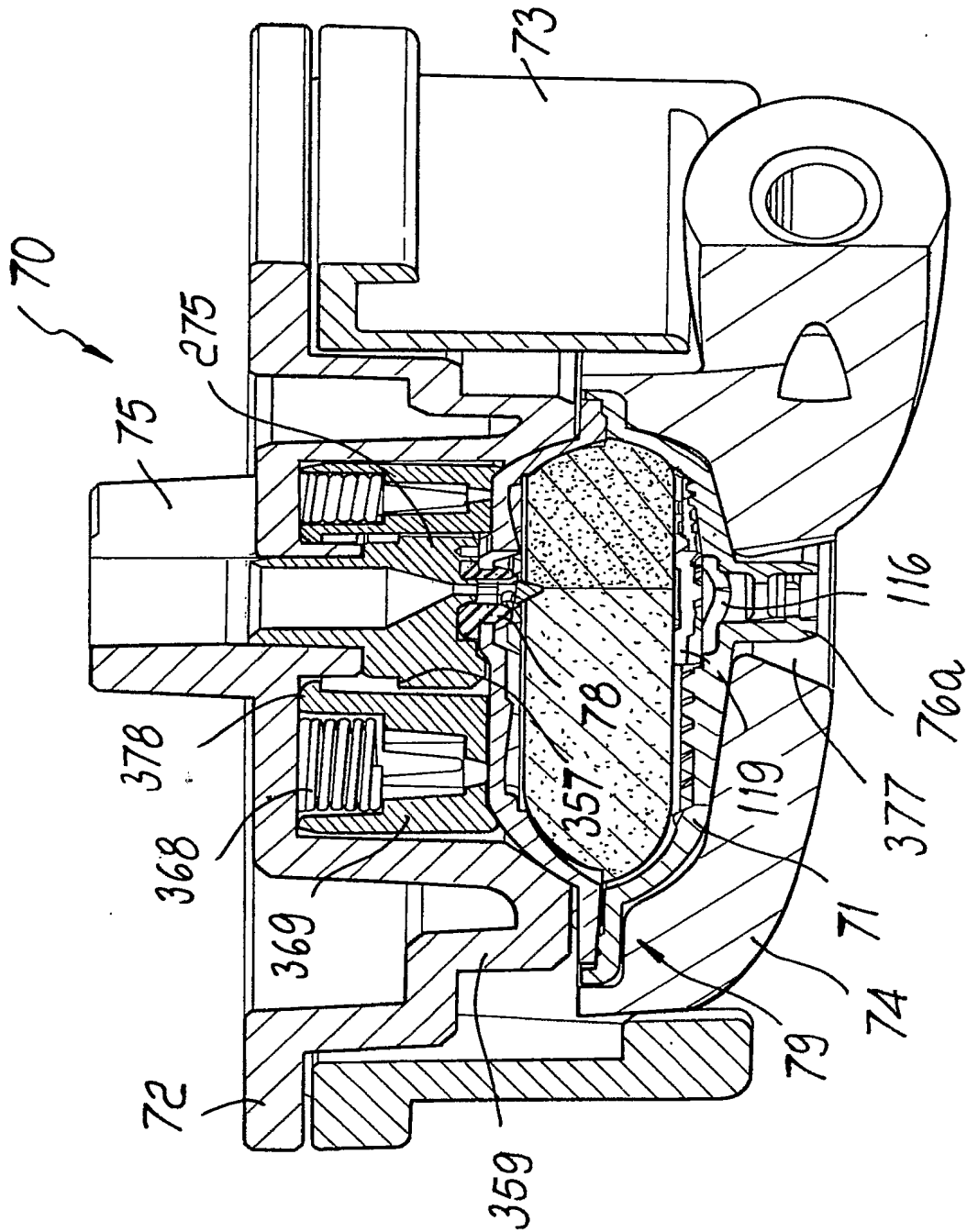
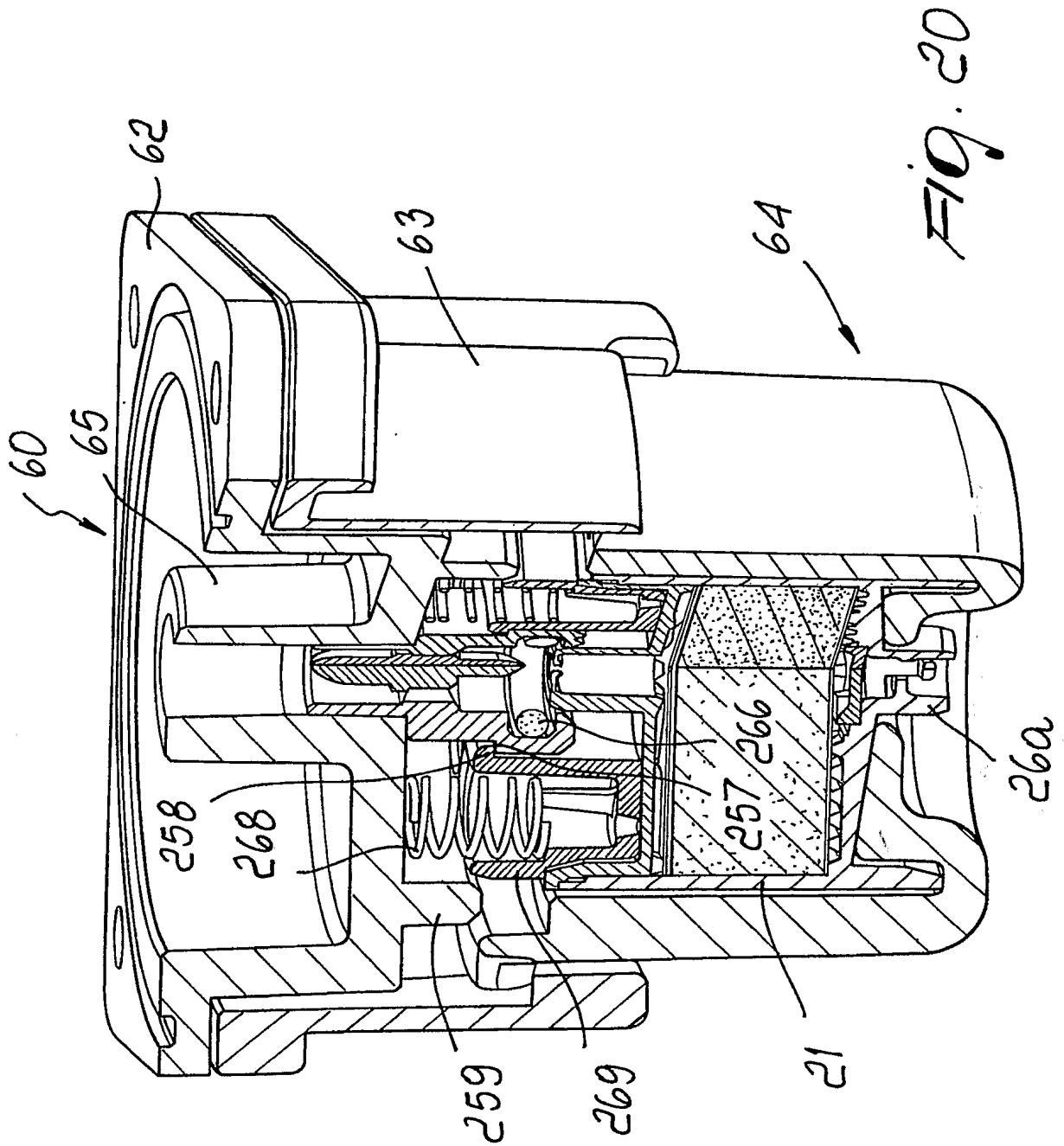
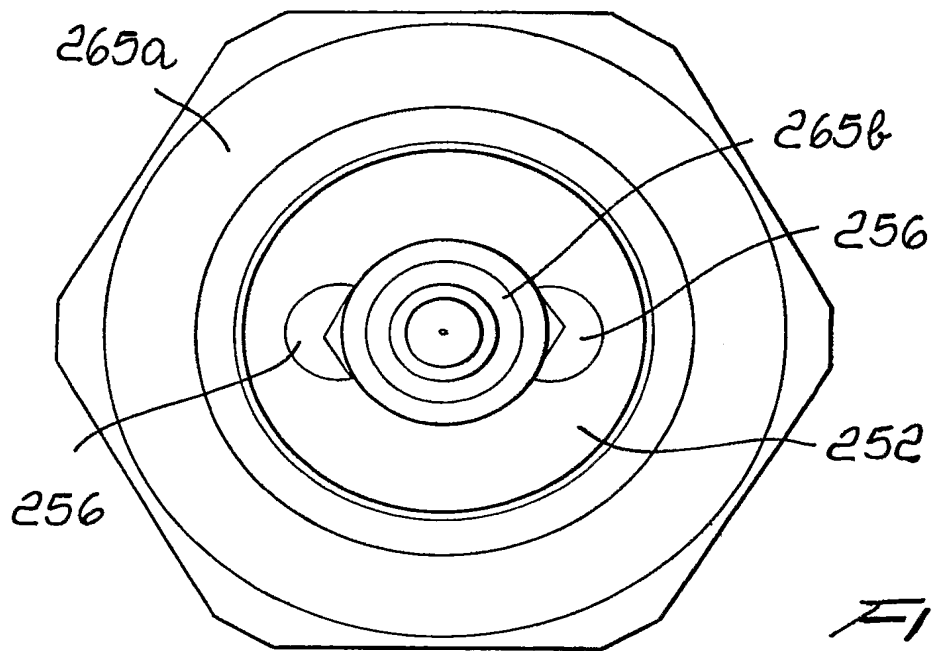
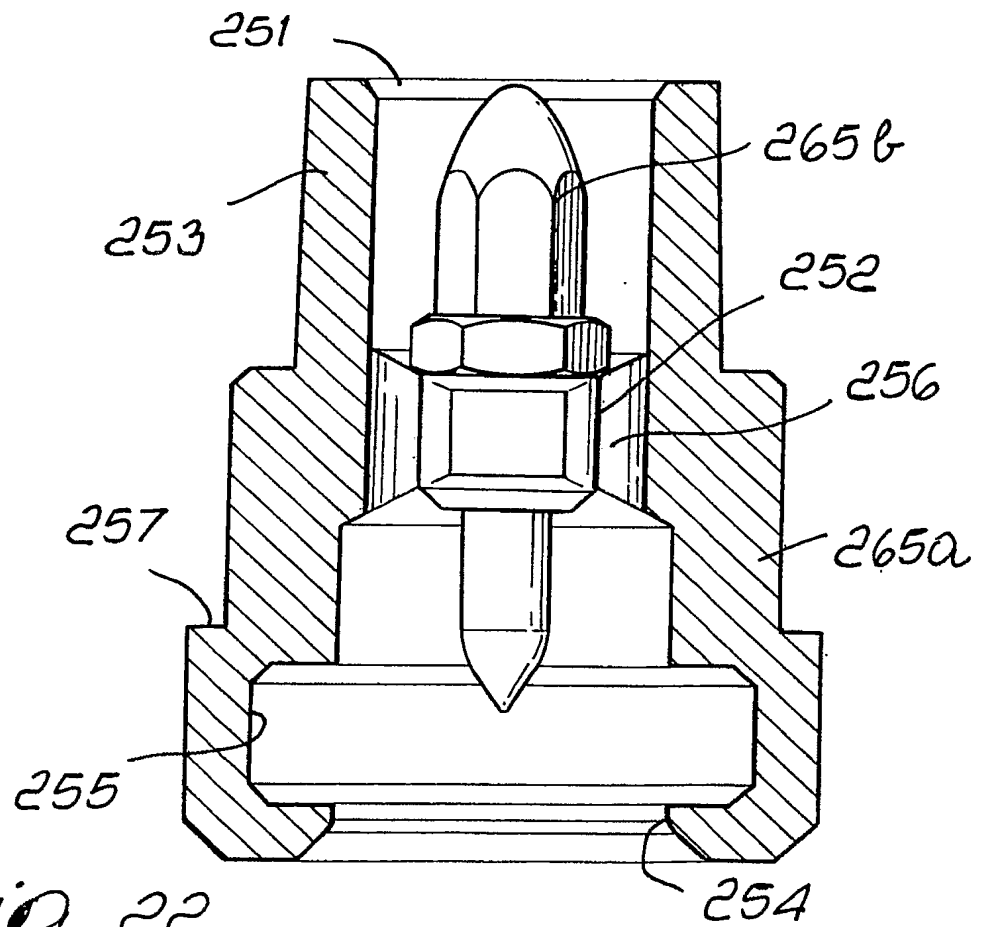


Fig. 17



*Fig. 19*



*Fig. 21**Fig. 22*

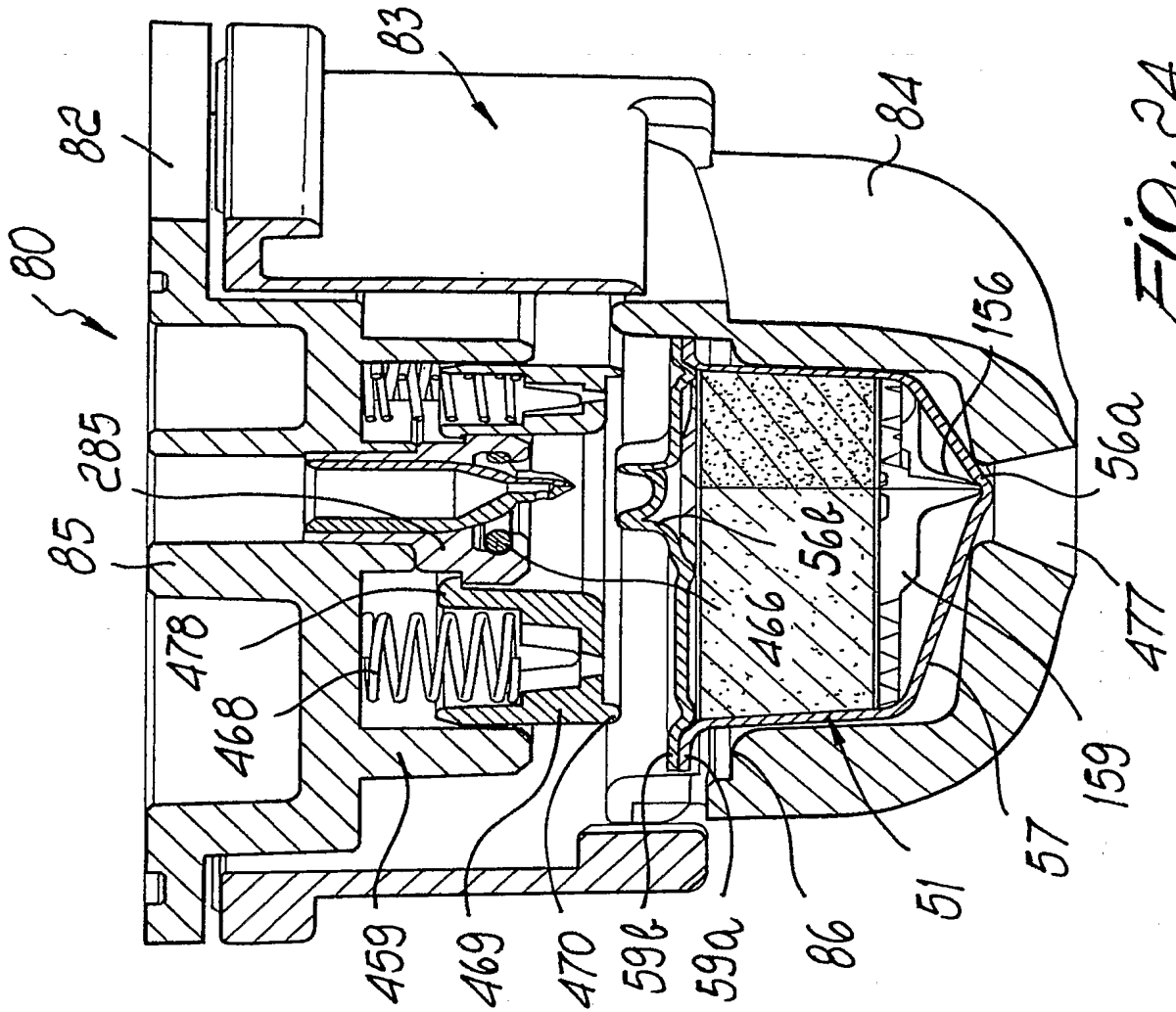


Fig. 24

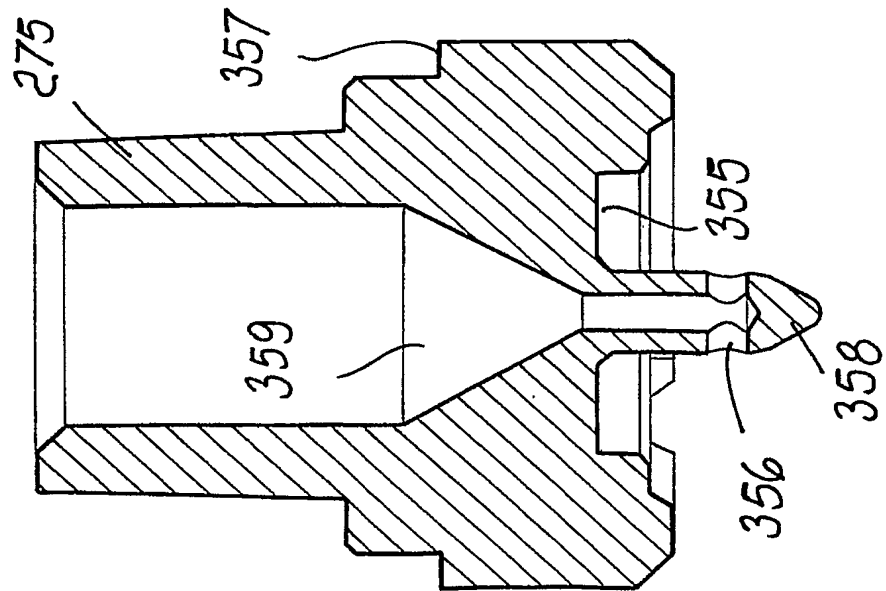


Fig. 23

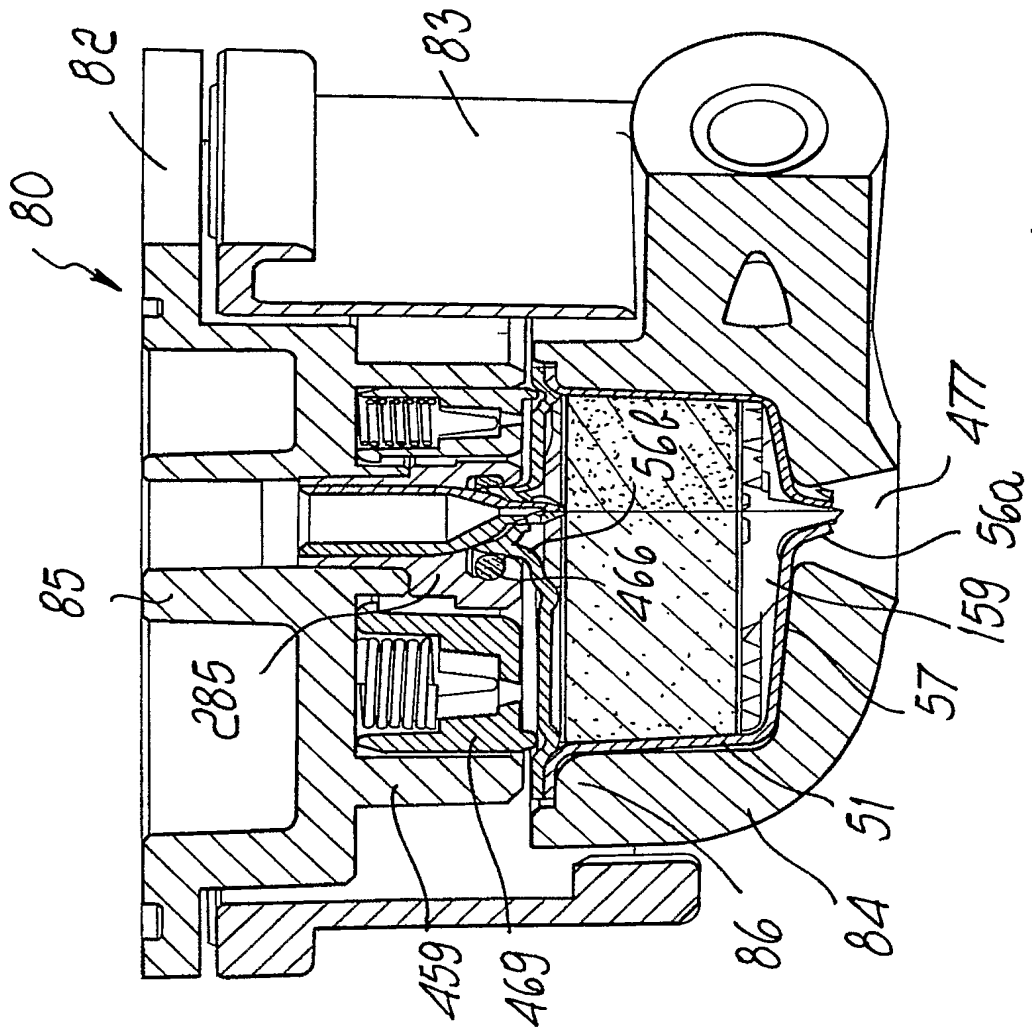


Fig. 25

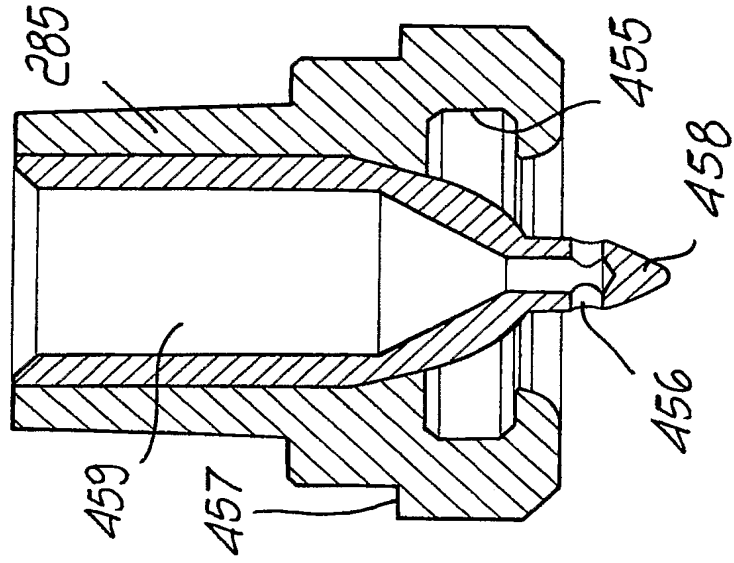


Fig. 26

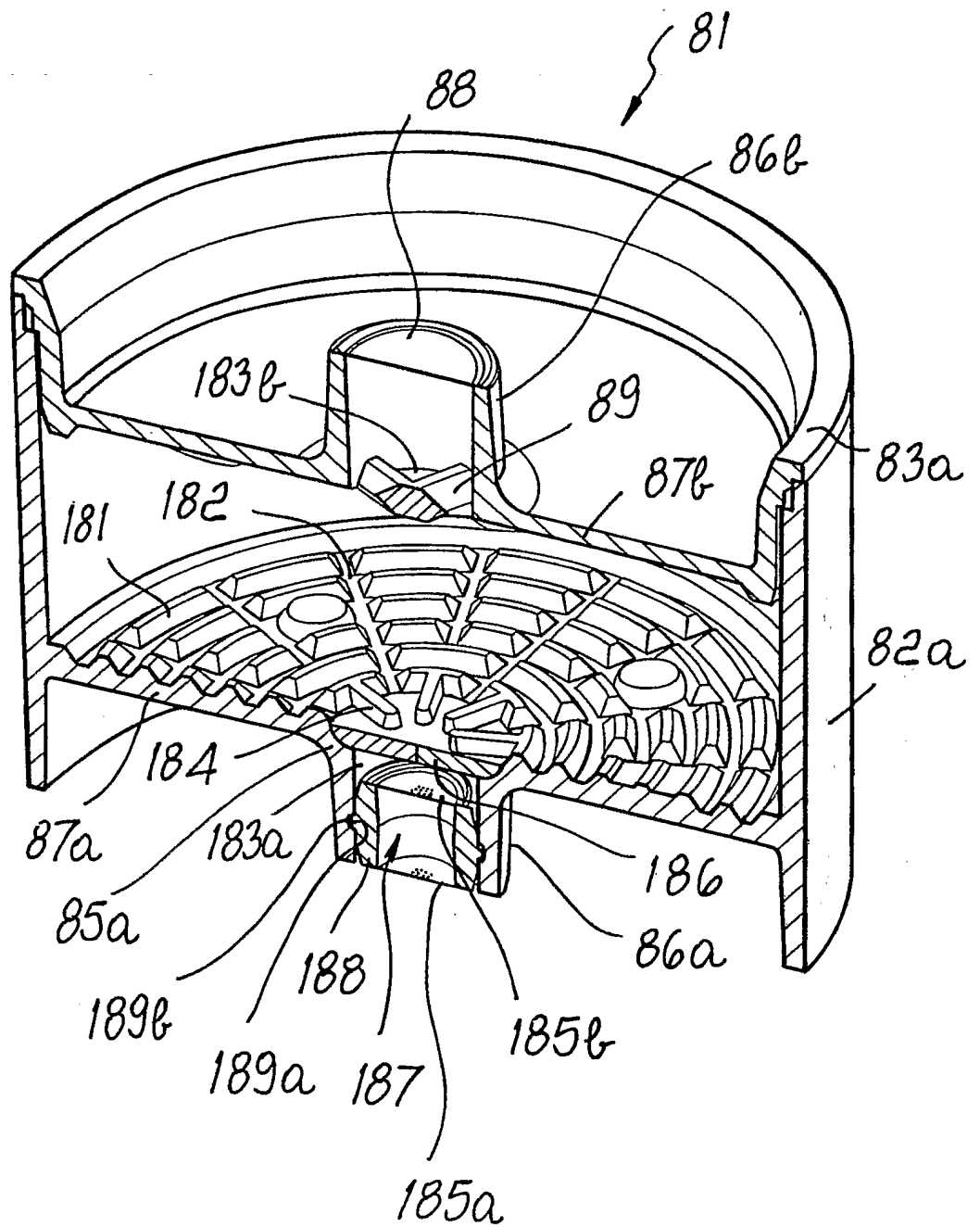


Fig. 27

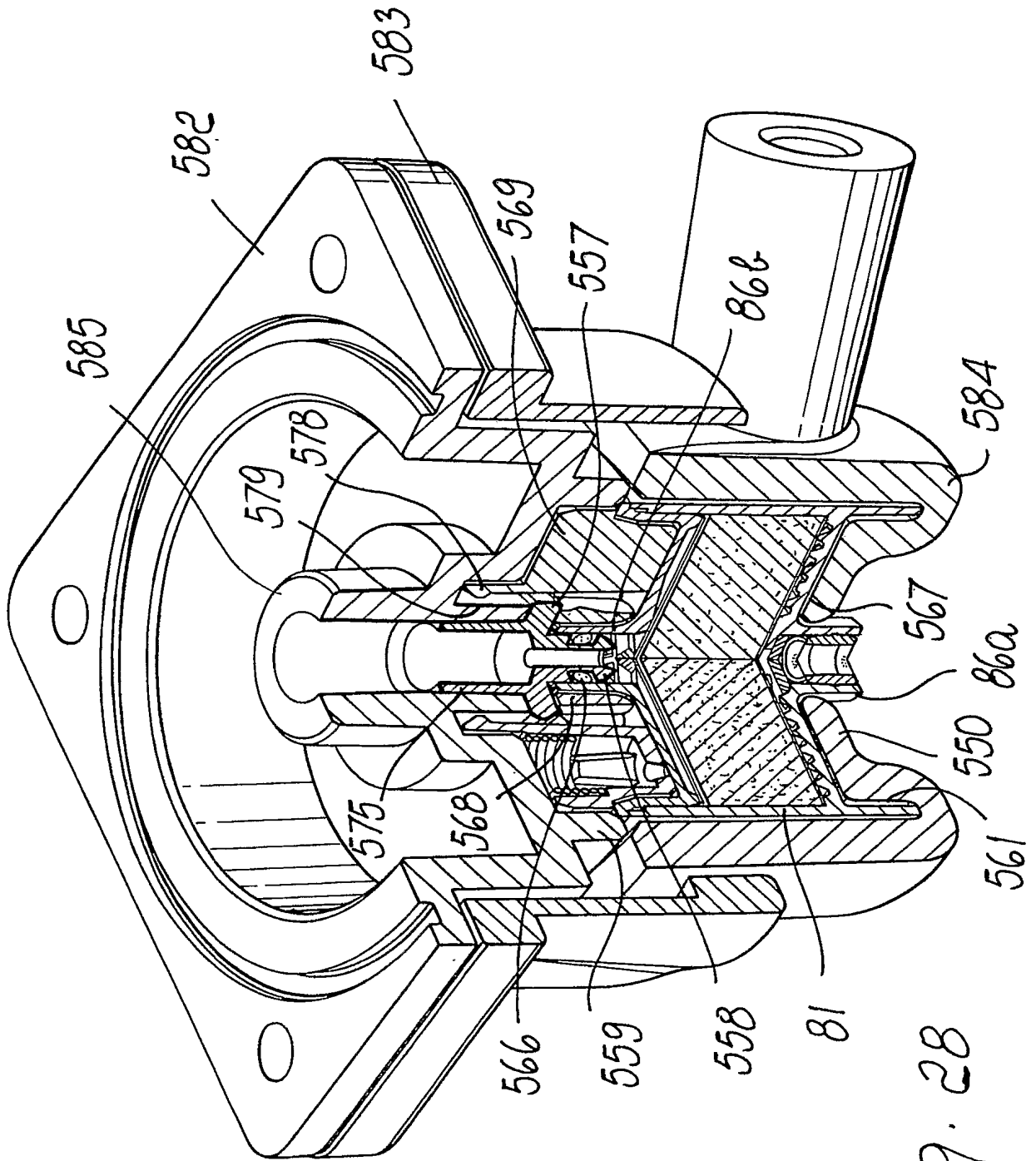


Fig. 28